Matscience

SEVEN YEAR REPORT

1962–1968

THE INSTITUTE OF MATHEMATICAL SCIENCES

MADRAS-20 (India)

The Institute of Mathematical Sciences
Madras

"THE PURSUIT OF SCIENCE IS AT ITS BEST
WHEN IT IS PART OF A WAY OF LIFE"

Seven Year Report
1962-1968

PATRON:

Mr. C. Subramaniam.

CHAIRMAN OF THE BOARD OF GOVERNORS:

Mr. V. R. Nedunchezhiyan

Minister for Education, Government of Madras.

DIRECTOR:

Professor Alladi Ramakrishnan

Board of Governors

1.	Mr. V. R. Nedunchezhiyan, Minister for Education, Government of Madras, Madras.	Chairman
2.	Mr. S. Krishnaswami, I.A.S., Secretary to Government, Education Department, Government of Madras, Madras.	Member
3.	Professor M. G. K. Menon, Director, Tata Institute of Fundamental Research, Bombay.	,,
4.	Professor Alladi Ramakrishnan, Director, The Institute of Mathematical Sciences, Madras.	,,
5.	Dr. R. Vasudevan, Permanent Member, The Institute of Mathematical Sciences, Madras.	,,
6.	Professor P. M. Mathews. Department of Physics, University of Madras, Madras.	,,

Finance Committee

1. Mr. S. Krishnaswami, I.A.S.,
   Chairman,
   Secretary to Government,
   Education Department,
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   Madras.

2. Mr. G. Ramachandran, I.A.S.,
   Secretary to Government,
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   Government of Madras,
   Madras.

3. Prof. Alladi Ramakrishnan,
   Director,
   The Institute of
   Mathematical Sciences,
   Madras.

4. Dr. R. Vasudevan,
   Permanent Member,
   The Institute of
   Mathematical Sciences,
   Madras.

Academic Council

1. Prof. Alladi Ramakrishnan
   Chairman,
   Director,
   The Institute of
   Mathmatical Sciences,
   Madras.

2. Dr. R. Vasudevan,
   Permanent Member,
   The Institute of
   Mathematical Sciences,
   Madras.

3. Dr. K. R. Unni,
   Permanent Member,
   The Institute of
   Mathematical Sciences,
   Madras.

4. Dr. N. R. Ranganathan,
   Associate Member,
   The Institute of
   Mathematical Sciences,
   Madras.

General Information

Aims and Objects

1. To create and provide an atmosphere and environment suitable for creative work and the pursuit of knowledge and advanced learning in the Mathematical Sciences for their own sake.

2. To promote and conduct research and original investigation on fundamental sciences in general, with particular emphasis on Mathematics, Applied Mathematics, Theoretical Physics and Astrophysics.

3. To foster a rigorous mathematical discipline, to stimulate a zest for creative work and cultivate a spirit of intellectual collaboration among academic workers in pure and applied branches of science.

4. To arrange lectures, meetings, seminars and symposia in pursuance of its academic work and for the diffusion of scientific knowledge.

5. To invite scientists in India and abroad actively engaged in creative work to deliver lectures and participate in academic activity.

The primary activity of the Institute is creative research in the mathematical sciences. In pursuance of the objectives of the Institute, weekly seminars as well as series of lectures on various topics of interest, both by visiting scientists and the academic staff of the Institute and opportunities are provided for leisurely discussion and exchange of ideas.

Academic activities

The Institute organises a Summer or Winter School in Mathematical Sciences in which lectures range from introductory to advanced levels. To commemorate the inauguration of the Institute an Anniversary Symposium is held in the first week of January in which scientists from India and abroad are invited to deliver one hour addresses summarizing their original work or recent advances in various branches of mathematical sciences.

Academic Staff

The academic group consists of Professors, Permanent Members and Associate Members of the various faculties, visiting scientists, temporary members, research fellows and research trainees.

Ph.D. Programme

Facilities are available for post-graduate students to work for the Ph. D. degree under the guidance of the academic staff of the Institute in various faculties. Senior and junior research fellowships are awarded by the Institute. Besides these, fellowships tenable at the Institute are awarded by the Department of Atomic Energy and Council of Scientific and Industrial Research.

The Standing Committee of Inter University Board of India and Ceylon at its meeting held on February 28, 1967 adopted a resolution recognising the Institute of Mathematical Sciences as a suitable centre for research work In view of the above resolution the Institute is now recognised by the various Indian universities as a centre for research for a doctorate degree in Theoretical physics and Mathematics.

Mode of admission

Memberships (temporary and permanent) of the Institute are made available on invitation or by application to the Director.

Students intending to become research trainees and research fellows of the Institute are expected to apply on prescribed forms which are supplied on request.

Visiting scientists programme

Facilities are offered to visiting scientists to spend a considerable time in the Institute and work in collaboration with the academic staff of the Institute.

Distinguished scientists of established reputation are invited by the Director on behalf of the Board of Governors as Visiting Professors of the Institute. They are expected to stay for six weeks or more.

The Visiting membership programme of the Institute is designed to enable young, active and promising scientists to pursue research and take part in various academic activities of the Institute. Such memberships are available on invitation or by request for such periods as may be fixed in consultation with the visiting members. Scientists intending to be admitted under this scheme can contact the Director of the Institute giving particulars of their academic career and indicating the probable period of their stay.

Besides the above, scientists from various institutions may be invited to deliver lectures and seminars for which suitable honorarium will be offered.

Publications :

1. **Research papers** (Preprints and reprints are available on request).

2. **Seminar lecture notes** (available on request).

3. **Matscience reports** based on the lecture courses delivered at the Institute both by visiting scientists and academic staff. (Price Rs. 5/- or U. S. $ 1·00 outside India).

4. Proceedings of the Summer School and the Anniversary Symposium published as a series entitled **"Symposia on theoretical Physics and Mathematics"** by the **Plenum Press,** New York.

Academic Staff

Faculty of Theoretical Physics

Permanent Staff

Professor Alladi Ramakrishnan — *Director*
Dr. R. Vasudevan — *Permanent Member*

Associate Member

Dr. N. R. Ranganathan

Members

Mr. T. S. Santhanam
Dr. K. H. Mariwalla
Dr. I. V. V. Raghavacharyulu
Dr. K. Ananthanarayanan
Dr. R. Pratap
Professor V. V. L. Rao*

Senior Research Fellows

Mr. K. Srinivasa Rao
Mr. S. Nagarajan

Junior Research Fellows

Mr. R. Sridhar
Mr. A. Sundaram
Mr. P. S. Chandrasekaran
Miss Nalini Menon†

Faculty of Pure Mathematics

Permanent Staff

Dr. K. R. Unni — *Permanent Member*

Junior Research Fellows

Mr. N. R. Nandakumar
Mr. M. R. Subrahmanya
Mr. G. N. Keshavamurthy
Miss P. K. Geetha†

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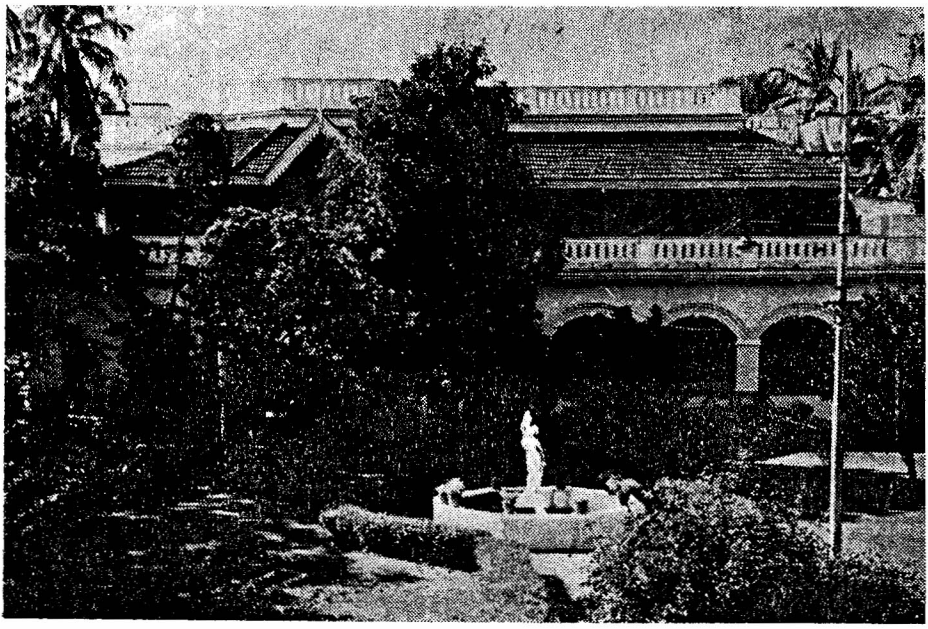
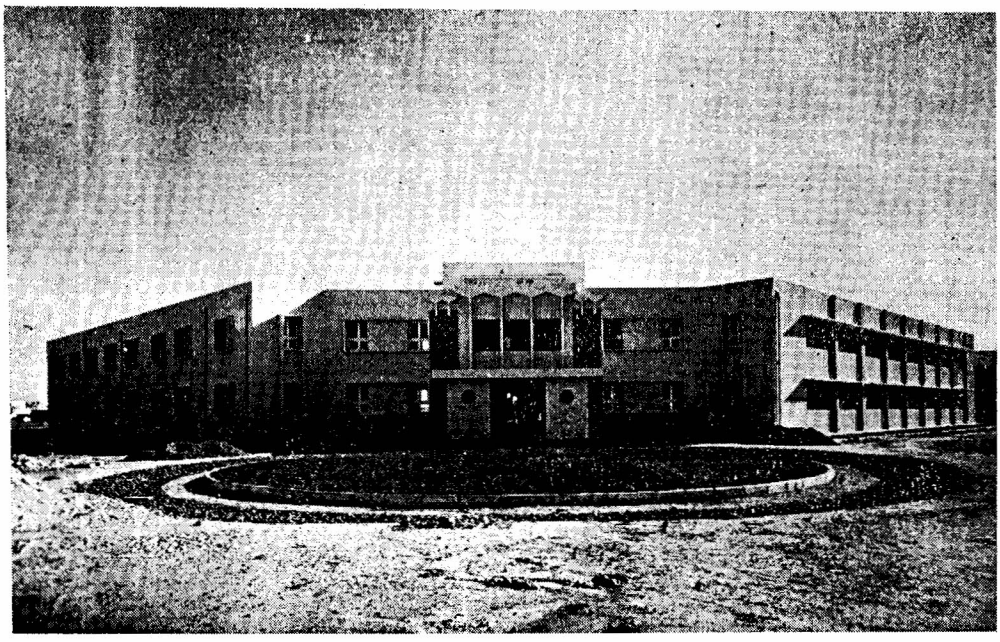
* Working under the C.S.I.R. Scheme

† C. S. I. R. Fellowship

" The origins of which may be traced to the informal discussions held in my family home almost twelve years ago by the 'Theoretical Physics Seminar'....."



" We are now entering into an imposing edifice in this magnificent technological campus "



SEVEN YEAR REPORT

1962 - 1969

From hope to reality

Seven years ago, in an atmosphere charged with hope and excitement, the birth of this Institute was hailed as the starting point of an intellectual renaissance the nature and consequences of which could not be foreseen at that time. Today, through God's grace, the combined endeavours of the sponsors and the academic group at Matscience have led us to a stage when our initial hopes have assumed shape and reality and we feel we are actively participating in the world-wide effort in mathematical sciences.

Thrice blessed

No institution for advanced learning in India and perhaps elsewhere in the world was created under more fascinating circumstances. The concept of such an institute was born in 1956 in the charming old town of Kyoto in the cherryblossom season of a Japanese spring and burst into a passion amidst the impatient, restless, competitive world of high energy physics. The Institute was born thrice blessed, by the benign interest of Professor Bohr in our work, the magnanimous gesture of Nehru in consenting to be its patron and the imaginative leadership of Subramaniam, its founding father.

A rewarding experience

While the Institute professes to promote research in mathematical sciences in all their ramifications from pure mathematics to its applications even to social sciences, its career commenced essentially with investigations in theoretical physics. This turned out to be a rewarding experience for we were able to complete a programme of work, the origins of which can be traced to the informal discussions held in my family home almost twelve years ago by the 'Theoretical Physics Seminar,' a group of eager students who formed the nucleus of the present Institute. We were at that time considered as late entrants into the stream of high energy physics which had received its greatest impulse with the triumphs of electrodynamics in 1949 and the discovery of

strange particles in the years that followed. Such a belated entry turned out to be a very fortuitous circumstance for we were able to view the developments following Feynman's significant contributions with diligent care and critical detail rather than with the exuberant faith in their completeness which characterised the work that immediately followed their first formulation. The result was the unfolding of new features of the Feynman graphical formalism hitherto obscured by an undue insistence on the manifest covariance of the theory.

Pleasant anxiety Quite unexpectedly our efforts also led to some mathematical investigations in matrix analysis in the construction of what we have now begun to call the L-matrix structure in which is imbedded the famous Dirac Hamiltonian. The peculiarities of the algebra of gamma matrices and the symmetries of the Dirac equation emerge as particular consequences of quite general mathematical results. Encouraged by this, we pursued a new line of work dealing with a generalisation of the Clifford algebra of matrices which were the higher roots of the unit matrix. We soon realised that the investigations would lead to no significant results unless the commutation relations were capable of generalisation. To our pleasant surprise we found that the work of a Japanese mathematician Yamazaki in 1964 provided us with just that mathematical result which would make our approach purposeful in its applications. It has now been possible to establish the connection between the generalised Clifford algebra and the unitary groups which are dominating phenomenological physics today. What is more, a connection with the well-known Kemmer algebra seems to emerge as a natural consequence. Obviously there is a pleasing anxiety to observe the reactions of the scientific community to these new and unconventional results.

Mathematician's attitude While working in theoretical physics we were quite conscious of our inadequacies and well aware of the all pervasive nature of the mathematical discipline. The preamble to the constitution of our Institute puts unambiguous emphasis on the development of mathematical sciences in the widest possible range. In January 1966, a significant beginning was made in pure mathematics in a

spirit so well expressed by Professor Marshall H. Stone, 'the mathematician's attitude to other disciplines such as physics is something like: "I try to help every one but I have also my own concerns."'

The vital impulse In planning the work of the Institute it was important to keep in mind that our objectives should not be circumscribed by our own special interests or limitations. The only safeguard against stagnation and sterility in creative effort is close contact with leaders of scientific thought, frequent exchange of ideas and a comparative study of the works of compeers elsewhere in the world. The steady influx of visiting scientists transmits to us the strong and vital impulses from the world of scientific thought in the mathematical sciences. The visiting scientists have made a three-fold contribution to the academic work of the Institute; first by their own research, sometime done in collaboration with the members of our academic group; secondly through systematic series of lectures which are made available to a wider community as Matscience Reports; thirdly by their active participation in our scientific meetings.

Scientific meetings Creative work thrives on competitive effort and in an un-compromising desire for excellence. The seminars, symposia and summer schools at the Institute provide the forum for a clash of intellects out of which emerges work of originality and invention which alone can claim the attention of the scientific world.

A generous gesture The academic activities of the Institute find outward expression not only through original contributions in research journals but through the Proceedings of the Symposia published as a continuing series by the Plenum Press of New York. The magnificent gesture of Earl Coleman, of the Plenum Press to undertake this arduous task is in consonance with the spirit of collaboration amongst the international scientific community. The more extended series of lectures are as usual published as Matscience Reports; the demand for which is as keen as ever from centres like Berkeley in the United States to Dubna in Soviet Russia.

Revival of hope

At the time of the inauguration I spoke of a splendid sickness that had stricken the academic group—the desire for stimulating an atmosphere for creative work in our country by our own exertions. For sometime I felt a little worried that this splendid sickness was being dispelled by the great opportunities in the affluent countries which are attracting away our young scientists in increasing numbers. But our hopes have been revived when we realised that our distinguished Chairman of the Board of Governors Mr. V. R. Nedunchezhiyan seems to have yielded to the same splendid sickness. His enthusiasm for mathematics can be best expressed through his own words:

> "If one ponders over it, one would be struck by the strange phenomenon that while mathematicians withdraw more and more from the masses and develop apparently abstract theories, their application brings out changes and developments that affect every aspect of our living."

We need not look for a better source of hope than this enlightened attitude towards mathematics which would do credit even to professional mathematicians.

Mansion with many facades

The mansion of mathematical sciences has many facades and can be approached from any direction. This temple of learning has therefore been conceived as a whole and is gradually being executed in parts. We have now our theoretical physics and pure mathematics faculties in good strength and form, thanks to the co-operation of the members of our permanent staff, Professors Vasudevan and Unni. Very soon we hope to initiate a programme of applications of mathematical methods to various domains including social sciences.

Summary of work

Let me summarise our work during the seven year period. Over one hundred papers have been published in leading scientific journals in the world; the Ph. D. programme is in full swing and twelve students have already taken their degrees and ten are working in pursuance of it. About two hundred visitors have participated in our visiting programme and scientific meetings.

Over sixty Matscience Reports have been published comprising lectures delivered by distinguished visitors, along with nine volumes of our symposia.

Blue riband

This record should justify our immodest enthusiasm in drawing the attention of our sponsors and making increasing demands for further facilities for research work. When we started this Institute, it was a soul without a body. As we are now entering into an imposing edifice in this magnificent technological campus, I must recount what I said at the inauguration of this Institute in grateful tribute to our State Government:

"It does not seem to be the red tape-it is the blue riband".

Our sponsors

We have been very fortunate in the succession of our Chairmen, Mr. C. Subramaniam Mr. R. Venkataraman and Mr. V. R. Nedunchezhiyan whose interest in the mathematical sciences is just an expression of the high level of intellectual appreciation in our country. Successive Chief Ministers of our State, Mr. K. Kamaraj, Mr. M. Bakthavatsalam and Mr. C. N. Annadurai have lent their full support to this Institute since its inception.

Our grateful thanks are due to Mr. T. Muthian, Director of Technical Education who has assisted us with the enthusiasm characteristic of our sponsors.

We look forward to the future with unconcealed enthusiasm and hope, especially since we are enjoying the full support of the three sponsors of scientific research, the Department of Atomic Energy of the Government of India; the Council of Scientific and Industrial Research and the Government of Madras. It is a source of particular pride to me that my great teacher, Professor Bhabha was a member of the Board of Governors at its inception and the support which the Department of Atomic Energy was giving us under his aegis will be augmented under the direction of the present Chairman, Dr. Vikram A. Sarabhai.

The Council of Scientific and Industrial Research was the first sponsor of the visiting membership programme which had unqualified success in setting the pace for creative work.

The Government of Madras, the proud parent of this institution will, in the tradition of our ancient land, soon be delivering the daughter into the hands of its new protector, the Government of India.

A time for dedication

In this festive mood of Pongal, we wish to initiate work in a spirit of dedication and grateful remembrance. Our thoughts recall the magic moment when the late Prime Minister Nehru expressed his great concern in the creation and the development of the Institute. It is a matter of pride that this concern has been transmitted successively to Lal Bahadur Shastri and then to our present Prime Minister Mrs. Indira Gandhi. On every occasion I meet her, she evinces keen interest which encourages us to believe that this Institute has earned its place as one of the national centres for international collaboration in science.

In this time of dedication let me draw the attention of my young colleagues to a remark made by my revered father in the momentous days of the Constituent Assembly ; "The success of a constitution depends not so much on those who draft it as on those who work it". This is just as true of a centre of advanced research the strength of which lies essentially in the creative talents of its academic staff.

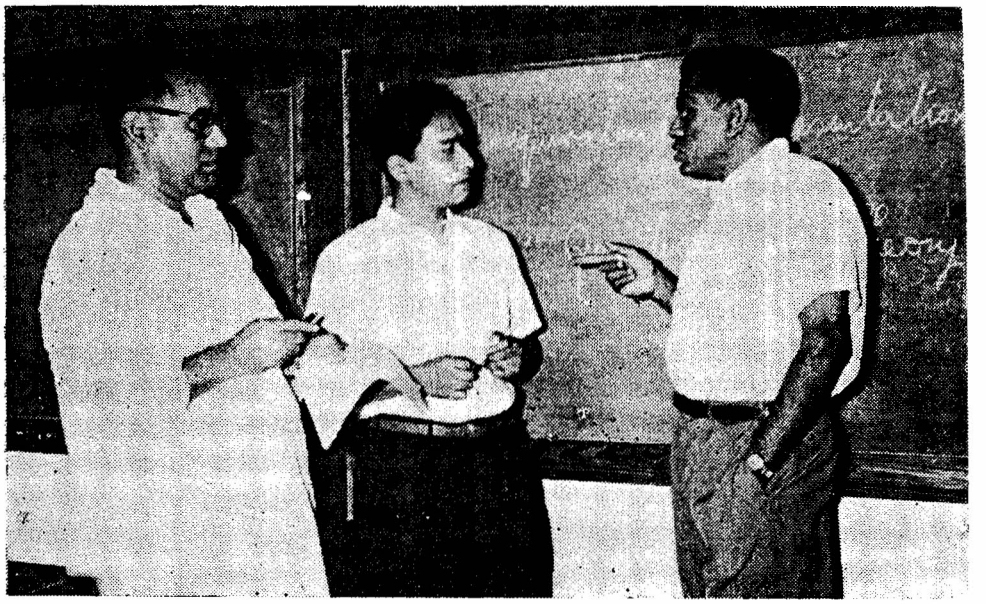
The second revolution

We must feel thankful to Providence that we are alive today to have witnessed the second revolution in human thought since the birth of science. The first occurred in the age of Galileo when man started observing heavenly bodies from his home, the earth. The second revolution has occurred now, four centuries later when the astronauts first observed the earth from an orbit round the moon—an achievement that baffles even the mind of man which knows no fetters.

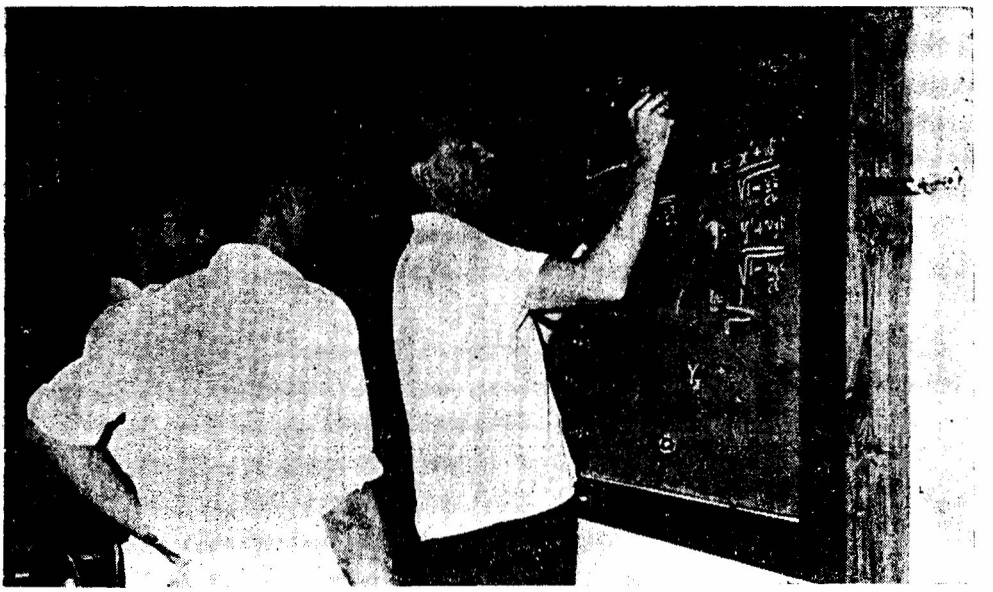
A way of life

Is it not a legitimate ambition to participate in this great adventure of the human mind ? The pursuit itself is thrilling, more so when it becomes a part of our way of life.

ALLADI RAMAKRISHNAN
Director.



Discussion after the seminar by Prof. Umezawa



Dr. R Hagedorn of CERN explaining to students after a lecture on "Relativistic kinematics"

Visiting Scientists Programme

Facilities are available for visiting scientists to spend a considerable time in the Institute and work in collaboration with the academic staff of the Institute. The success of this programme can be gauged from the fact that about 250 scientists from twelve countries as well as from leading research Institutions and universities in India have visited the Institute and stayed with us for periods ranging from a day to six months or more.

Visiting Professors :

Distinguished scientists of established reputation are invited by the Director on behalf of the Board of Governors as visiting professors of the Institute. They are expected to be resident at the Institute for a period of six weeks or more.

During the years 1962–68, fifty-five eminent scientists from nine countries working in Elementary Particle Physics, Manybody problems, Quantum Field Theory and different branches of pure mathematics, have visited us. Forty-one Matscience Reports based on their lectures are already available and further are reports under preparation.

Visiting Members :

The visiting membership of the Institute is designed to enable active and promising scientists to pursue research and take part in the academic activities of the Institute. These memberships are available on invitation or by request for such periods as may be fixed in consultation with the visiting members. Scientists are expected to be resident at the Institute for a period of three months or more

Thirty-two scientists from ten countries and ten scientists from universities and research institutions within India have stayed at the Institute for various periods ranging from one month to one year. The Institute has so far published ten Matscience Reports

based on their lectures. Many of the scientists have also published research papers during their stay at the Institute.

This programme was made possible between 1963-64 by the Council of Scientific and Industrial Research and from 1964 by the Department of Atomic Energy, Government of India.

Invited Lecturers :

Active scientists in various branches of mathematical sciences are invited to deliver a few seminars at the Institute for which suitable honorarium is offered. More than one hundred scientists have visited the institute under this scheme. Two Matscience Reports based on these seminars, one in Pure Mathematics and one in Physics have been issued.

Distinguished Visiting Professorships :

Niels Bohr Visiting Professorship and Ramanujan Visiting Professorship :

Two professorships entitled "Niels Bohr Visiting Professorship" and "Ramanujan Visiting Professorship" were established in the year 1963.

The first is a tribute to the memory of the creator of modern physics and the founder of quantum theory whose life has been a glorious example of the universality of science and the eternal quest for the laws of nature. His benign interest in the advancement of Indian science and in particular the work of the group of theoretical physicists at Madras was the immediate stimulus for the creation of our Institute.

The second visiting professorship "Ramanujan Visiting Professorship" is to honour the greatest mathematician India has produced.

Jawaharlal Nehru Visiting Professorship :

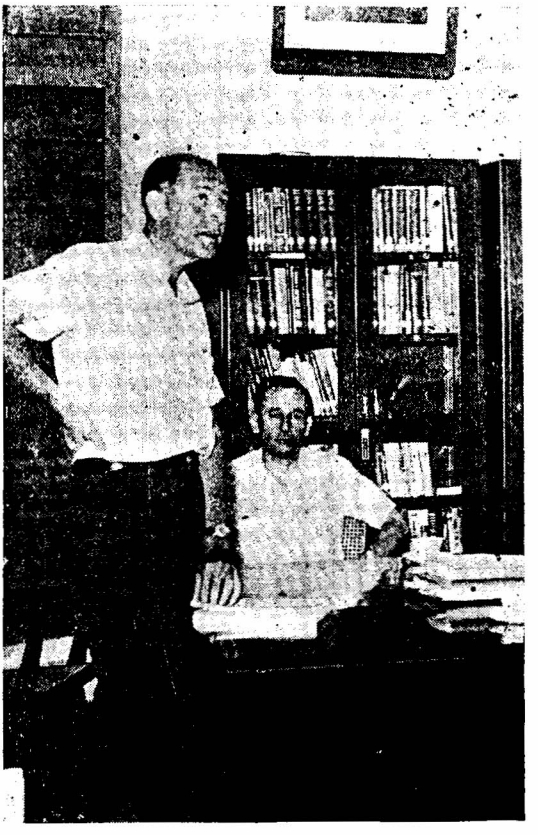
As a tribute to our benignant sponsor, the late Jawaharlal Nehru, a visiting professorship was created in his name in 1966.

Niels Bohr Visiting Professors :

Prof. R. E. Marshak, U.S.A.	1963
Prof. L. Rosenfeld, Netherlands	1964

Ramanujan Visiting Professors :

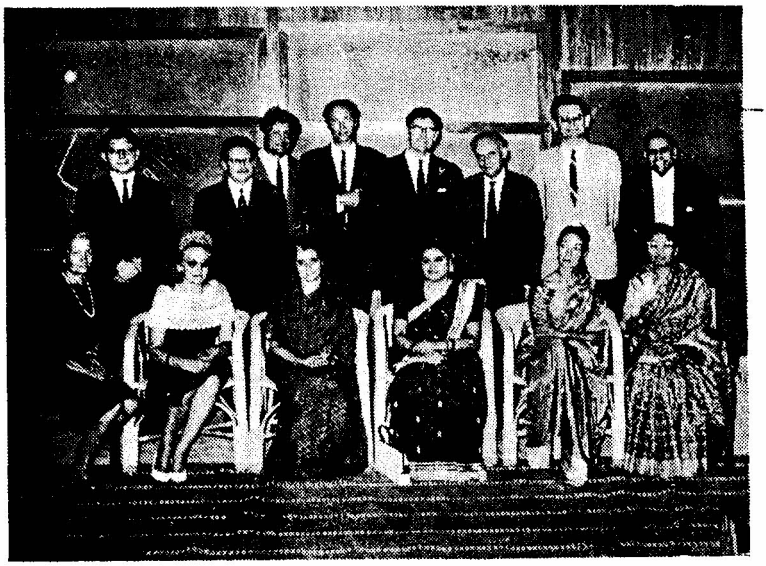
Prof. M. H. Stone, U.S A.	1963



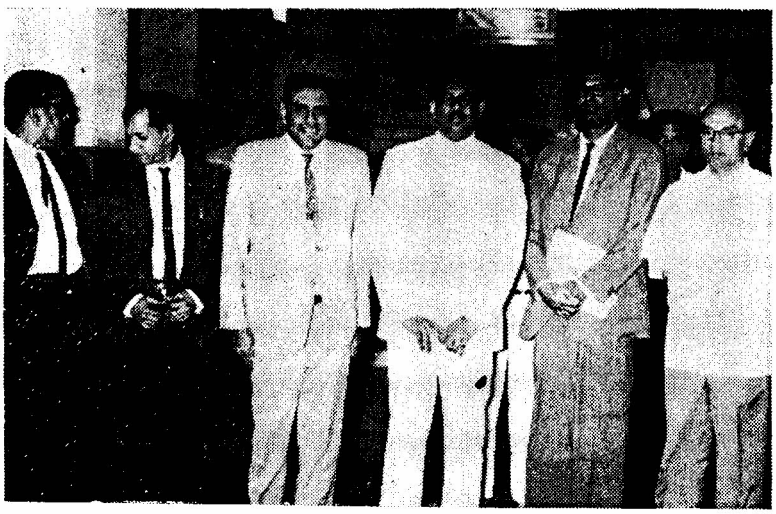
Prof. R. E. Marshak, first Niels Bohr Visiting Professor, and Prof. L. I. Schiff who released the first Matscience Report

'mathematicians attitude to the other disciplines such as physics and economics...is some thing like : I try to help every one, but I have also my own concerns'

Prof. M. H. Stone discussing the current trends in mathematical research



Srimathi Indira Gandhi, Prime Minister with the visiting scientists at the Institute



Mr. V. R. Nedunchezhiyan, Chairman Board of Governors with the Director

Visiting Scientists

Visiting Professors

	Theoretical Physics	*Mathematics*
1962		
	E. C. G. Sudarshan (U. S.)	
	N. Fukuda (Japan)	
1963		
	R. E. Marshak (U. S.)	
	L. I. Schiff (U. S.)	
	H. Umezawa (Italy)	
	A. T. Bharucha-Reid (U. S.)	
	Paul Roman (U. S.)	M. H. Stone (U. S.)
	Peter Dürr (Germany)	Shreeram Abhyankar (U. S.)
	R. Hagedorn (Switzerland)	
	G. D. Rochester (U. K.)	
	A. W. Wolfendale (U. K.)	
	E. C. G. Sudarshan (U. S.)	
	L. Rosenfeld (Denmark)	
1964		
	B. Zumino (U. S.)	
	McCrea Hazlett (U. S.)	
	J. B. Keller (U. S.)	
	E. R. Caianiello (Italy)	
	K. Symanzik (U. S.)	
	R. Oehme (U. S.)	M. H. Stone (U. S.)
	W. Brenig (Germany)	
	Ph. Meyer (France)	
	C. Dominicis (France)	
	Victor Weisskopf (Switzerland)	

1965

G. Goldhaber (U. S.)
Y. Takahashi (Ireland)
J. Rzewuski (Poland)
G. Kallen (Sweden)

Richard Arens (U. S.)

1966

B. Vitale (Italy)
E. C. G. Sudarshan (U. S.)
G. Rickayzen (U. K.)
N. Dallaporta (Italy)
M. Gourdin (France)
D. G. Ravenhall (U. S.)

W. K. Hayman (U. K.)
J. H. Williamson (U. K)

1967

M. Moshinsky (Mexico)
J. I. Horvath (Hungary)
R. H. Good (U. S.)
S. Devons

H. S. Shapiro (U. S.)
D. Gaier (Germany)
W. H. J. Fuchs (U. S.)
L. A. Rubel (U. S.)

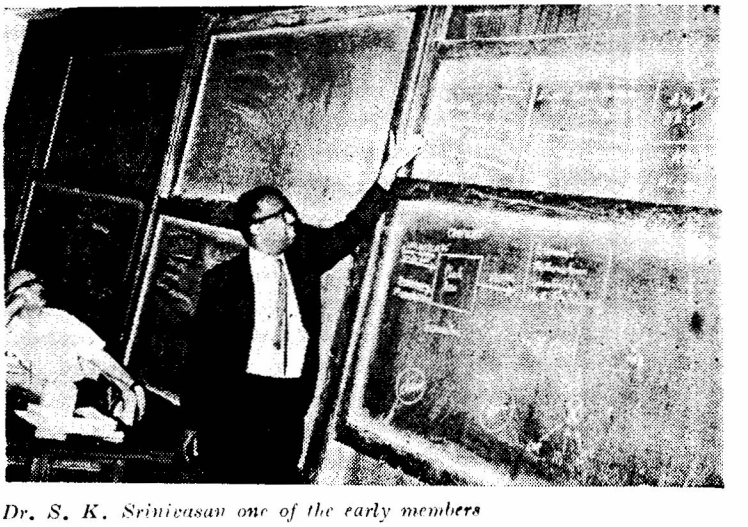
1968

S. Okubo (U. S.)
Myron Bander (U. S.)
J. L. Lebowitz (U. S.)
I. Prigogine (Belgium)
E. C. G. Sudarshan (U. S.)

A. M. Lee (Canada)
Tord H. Ganelius (Sweden)
Jan Krzyż (Poland)

'The steady influx of visiting scientists transmits to us the strong and vital impulses from the main stream of scientific thought in the physical sciences today'

Dr. M. M. Shapiro of U.S., and Prof. E. L. Feinberg of Moscow



Dr. S. K. Srinivasan one of the early members of the Theoretical Physics Seminar now Professor at I. I. T. Madras, lecturing on "stochastic processes" at the Institute.

Visiting Members

Theoretical Physics

1963

S. Kamefuchi (Japan)
Hugh Dewitt (U. S.)
M. Jacob (France)
L. O'Raifeartaigh (Ireland)

1964

E. Yamada (Japan)
H. P. Stapp (U. S.)
J. Lukierski (Poland)
A. Fujii (Japan)
F. Calogero (Italy)
K. Dietz (Switzerland)
M. Gourdin (France)
P. T. Landsberg (U. K.)

1965

A. Grossman (France)
R. J. Oakes (U. S.)
B. Gruber (Italy)
L. Picman (Yugoslavia)
J. J. De Swart (Netherlands)
V. L. Teplitz (Switzerland)
S. Kichenassamy (France)
H. Ruegg (Switzerland)
T. Kotani (Japan)
S. Goldhaber (U. S.)

1966

M. E. Arons (U. S.)
M. Scadron (U. K.)
Charles Joachain (Belgium)
F. Pham (Switzerland)
G. Charpak (Switzerland)

1967

F. A. Hinchey (U. S.)
David Atkinson (U. S.)
D. A. Dubin (U. K.)
Gordon Shaw (U. S.)

1968

B. Gruber (U. S.)
W. Drechsler (Switzerland)

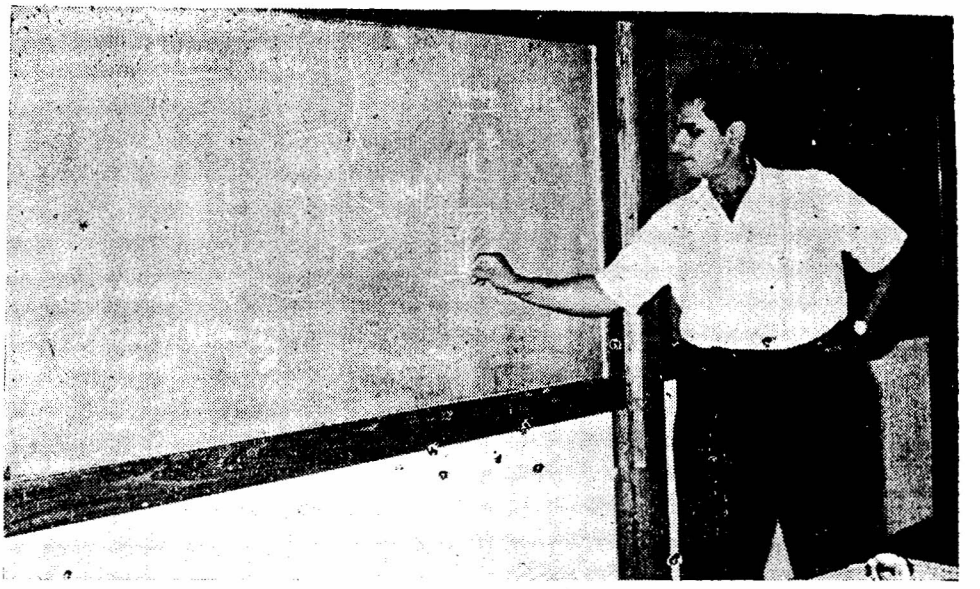
Pure Mathematics

1966

W. A. Katifi (U. K.)

Invited Lecturers

Theoretical Physics	*Pure Mathematics*
1962	
U. Fano (U. S.)	
C. Bloch (France)	
B. Maglic (U. S.)	
S. Frautchi (U. S.)	D. G. Bourgin (U. S.)
P. K. Kabir (U. S.)	R. Venkataraman (Madras)
E. Segre (U. S.)	S. Swaminathan (Madras)
R. K. Guy (Delhi)	
Skyrme (U. K.)	
A. N. Mitra (Delhi)	
1963	
Skyrme (U. K.)	
Charles Zemach (U. S.)	
G. Takeda (Japan)	E. Hille (U. S.)
K. Singwi (U. S.)	M. Venkataraman (Madurai)
F. Yekutili (Israel)	
M. M. Shapiro (U. S.)	
E. N. Hafner (U. S.)	
1964	
F. Mohling (U. S.)	
J. L. Jenson (Germany)	
Y. V. Novozhilov (U.S.S.R.)	
D. R. Inglis (U. S.)	
R. Reeves (U. S.)	M. Thomson (U. S.)
Alf Sjolander (Sweden)	
L. A. P. Balaz (Bombay)	
Virendra Singh (Bombay)	
A. N. Mitra (Delhi)	

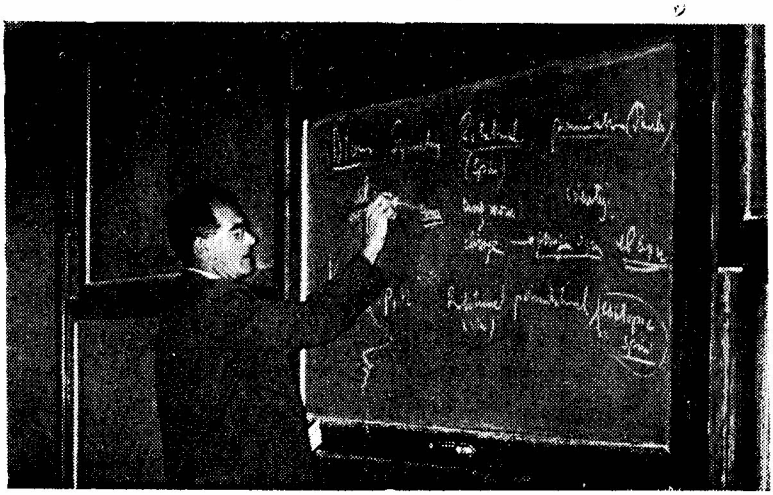


Prof. Shreeram Abhyankar, Distinguished Service Professor a
***Purdue University, delivering** a lecture at Matscience.*

'What are elementary particles made of?
They are made of fields of lie algebra'

Prof. E. C. G. Sudarshan, leading a symposium
on "Faster than light particles"

'The science of elementary particles has in recent years naturally become the most fundamental of all pursuits in physics...The most dominant in this trend is the concept of symmetry...'



Prof. Victor Weisskopf, giving a lecture at Third Anniversary Symposium

" Arrow of time would point the right way."

Dr. J. V. Narlikar lecturing on recent developments on cosmology

1965

R. Blankenbecler (U. S.)
Y. M. Shirokov (U. S. S. R.)
R. H. Capps (Italy)
Jastram (U. S.)
K. Symon (U. S.)
Nielson (U. S.)
G. Marx (Mexico)
S. Gheorghita (Rumania)
R. Narasimhan (Bombay)
R. R. Daniel (Bombay)
B. M. Udgaonkar (Bombay)
J. V. Narlikar (U. K.)
V. Radhakrishnan (Bombay)
Ram Gnanadesikan (U. S.)
A. P. Balachandran (U. S.)
M. G. K. Menon (Bombay)
V. K. Balasubramaniam, (U.S.)
Harish Chandra (U. S.)
N. Jacobson (U. S.)
J. L. Kelley (U. S.)
S. Meenakshisundaram (Waltair)

1966

P. Noziers (France)
A. Mercier (Switzerland)
B. J. Moyer (U. S.)
A. M. Sessler (U. S.)
H. J. Horvath (Hungary)
J. V. Narlikar (U. K.)
P. Babu (Bombay)
P. C. Vaidya (Ahmedabad)
P. L. Jain (Ahmedabad)
K. Gopalan (Bangalore)
S. Ranganathan (U. S.)
B. M. Udgaonkar (Bombay)
A. N. Mitra (Delhi)
Louis Sucheston (U. S.)
E. G. Straus
Pl. Kannapan (Annamalai)
V. Krishnamurthy (Palani)
Z. Govindarajulu (U. S.)
S. Swaminathan (Kanpur)
S. D. Nigam (Madras)

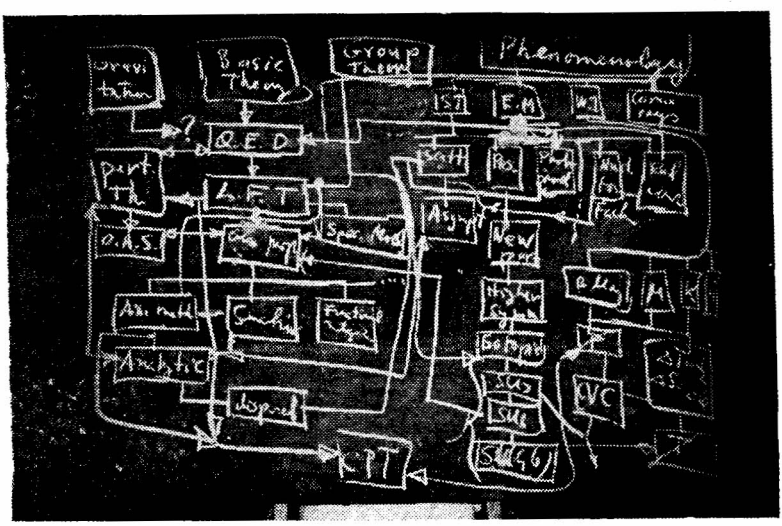
1967

J. Eliezer (Malaya)
D. L. Falkoff (U. S.)
M. G. Veselov (U. S. S. R.)
A. S. Galiullin (U. S. S. R.)
Y. V. Novozhilov (U.S.S.R.)
R. J. Elliott (U. K.)
Ferris-Prabhu (U. S.)
M. Rho (France)
K. V. Prasad (England)
Khalatnikov (U. S. S. R.)
S. P. Misra (Orissa)
V. Radhakrishnan (Bombay)
S. C. K. Nair (Calcutta)
G. Venkataraman (Bombay)
R. Ramachandran (Bombay)
D. M. Chibisov (U. S. S. R.)
V. V. Sazonov (U. S. S. R.)
K. Athreya (U. S.)
F. A. Hinchey (U. S.)
S. P. Franklin (U. S.)
S. G. Deo (Aurangabad)
V. Syamala Devi (Waltair)
K. S. Padmanabhan(Annamalai)
N. V. Subramanyam (Waltair)

1968

M. M. Sutton (U. S.)
M. F. Merriam (U. S.)
M. A. Braun (U. S. S. R.)
M. R. Bhagavan (U. K.)
Herbert Steiner (U. S.)
B. R. Srinivasan (Trivandrum)
S. C. K. Nair (Calcutta)
Ramanna (Bangalore)
M. K. Pal (Calcutta)
S. R. Valluri (Bangalore)
S. Nagarajan (Bombay)
A. P. Balachandran (U. S.)
Kailash Kumar
R. Narasimha (Bangalore)
S. Durvasula (Bangalore)
J. Pasupathi (Bombay)
Shreeram Abhyankar (U. S.)
Arthur Sard (U. S.)
K. Srinivasacharyulu (Canada)
R. A. Rankin (U. S.)

Sir C. P. Ramaswami Aiyer, with Prof. Gunnar Kallen of Sweden



Modern physics as seen by Prof. Gunnar Kallen, University of Lund, Sweden

Matscience Summer Schools

In addition to its research activity, the Institute organises a summer school each year for a period of three weeks during the months of August-September in which the lectures range from introductory to advanced levels, both in theoretical physics and pure mathematics, the aim being to introduce the participants to current developments. A significant feature of these summer schools is the equal participation in the lecture programme, of foreign scientists and representatives from Matscience and other Indian institutions.

The first summer school was organised under the auspices of the Council of Scientific and Industrial Research at Kodaikanal but the other four summer schools held at Bangalore and Madras were organised by Matscience with the financial support of the Council of Scientific and Industrial Research and Department of Atomic Energy. The participants of the summer school came from various educational institutions from all parts of India and among them were lecturers from colleges offering M.Sc. courses and young research workers.

Twenty scientists from seven different countries have delivered lectures on diverse topics on recent trends in theoretical physics. Scientists from various institutions in India, have also been invited to deliver lectures at the summer schools.

Matscience Anniversary Symposia

To commemorate the inauguration of the Institute an anniversary symposium is held during the first week of January in which scientists from India and abroad are invited to deliver one hour addresses either summarizing their recent original work or reviewing some of the current advances in different branches of mathematical sciences.

Six symposia have been held in which about forty scientists, both physicists and mathematicians from various countries, have participated.

Seminar in Analysis

One of the special features of this Institute is a Seminar in Analysis conducted by the Faculty of Mathematics each year for a period of three weeks in December - January, supported by a special grant from Department of Atomic Energy, Government of India. This Seminar is intended for the mathematicians and students engaged in study and research at the pre-doctoral and post-doctoral levels. Participants come from various institutions and universities in India. This is the first seminar in mathematics of its type started in India.

	PRINCIPAL LECTURERS	TOPICS
FIRST SEMINAR		
December 1967 January 1968	Prof. W. H. J. Fuchs	'Meromorphic function of lower orders less than one'.
	Prof. L. A. Rubel	'Victor space of analytic functions'.
	Prof. K. R. Unni	'Bernstein approximation problem'.
SECOND SEMINAR		
December 1968 January 1969	Prof. T. H. Ganelius	'Tauberian remainder theorems'.
	Prof. J. Krzyż	'Extremal length and quasi-conformal mapping'.
	Prof. O. Lehto	'Topics in quasi-conformal mapping'.
	Prof. K. R. Unni	'Polynomials'.

In addition participants also contributed to the success of the seminar by offering one hour lectures on the topics of their interest.

Matscience Symposia

on

Theoretical Physics and Mathematics

ALLADI RAMAKRISHNAN, EDITOR

(*Published by the Plenum Publishing Corporation, N.Y., U.S.A.*)

The series incorporates the proceeedings of the scientific meetings held every year at the Institute - the Anniversary Symposia in January and the Summer Schools in August. Stressing "recent advances in theoretical physics and mathematics" these volumes cover topics in various branches of mathematical sciences and pure mathematics

Volume 1: **Proceedings of the First Anniversary Symposium 1963**

This symposium was arranged as a tribute to Prof. R. E. Marshak, who accepted the first Niels Bohr visiting professorship. Prof. Marshak contributed the paper "Group Symmetries with R-Invariance", included in these proceedings. The other 11 papers also deal mainly with complex problems of particle symmetry and resonances.

Volume 2: **Proceedings of the Second Anniversary Symposium 1964**

The nineteen papers cover various aspects of elementary particle physics and some special topics in the many-body problem. A special feature is the inclusion of lectures on current trends in mathematical research, semigroup methods in mathematical physics, and other mathematical topics. Symmetry, Lie groups, spin states, elastic scattering, high-energy processes, Regge poles, weak interactions, three nucleon systems, muon capture, statistical mechanics of plasmas, electrodynamics of superconductors, and quantum statistics are all discussed.

Volume 3: **Proceedings of the First Matscience Summer School 1964**

This volume contains a number of important lectures by internationally eminent physicists on currently active topics in their areas of research.

Volume 4: **Proceedings of the Third Anniversary Symposium 1965**

It is devoted mainly to various topics in elementary particle physics, including many-body problems, with a supplementary programme in mathematics.

Volume 5: **Proceedings of the Second Matscience Summer School 1965**

Among the reviews highlighting this volume are papers on weak interactions, the present state of general relativity, the homology theory of Feynman integrals, and nested Hilbert spaces. Dealing with recent advances in theoretical physics and mathematics, this volume presents authoritative reviews and research papers delivered by internationally eminent scientists from various countries.

Volume 6: **Proceedings of the Fourth Auniversary Symposium 1966**

This volume contains papers relating to elementary particle interactions, many-body problems, and theories of cosmology. Especially noteworthy in this volume is inclusion of papers presented by research workers on detailed surveys of their investigations.

Volume 7: **Proceedings of the Third Matscience Summer School 1966**

Topics of special interest discussed in this volume include the application of algebraic topology to the study and location of singularities of multiple scattering processes, and the latest theory of superconductivity.

Volume 8: **Proceedings of the Fifth Anniversary Symposium 1967**

Topics discussed include quasars, Dirac groups, the kinetic theory of gases, functional differential equations, and Raikov systems. Offering rigorous approaches to some of the most fundamental aspects of contemporary theoretical physics and mathematics, this work, will serve as a basic source of current thought.

Volume 9: **Proceedings of the Sixth Anniversary Symposium 1968**

This volume represents the proceedings of the Sixth Anniversary Matscience Symposium on Theoretical Physics held in January 1968 as well as the "Seminar in Analysis" held earlier in December 1967. A new feature of this volume is that it includes also contributions dealing with applications of mathematics to domains other than theoretical physics. Accordingly the volume is divided into three parts, Part I dealing with theoretical physics, Part II with Applications of mathematical methods and Part III with pure mathematics.

(in print)

Volume 10: **Proceedings of the Fourth Matscience Summer School 1968**

(under preparation)

Matscience Library

During these seven years the Library has expanded rapidly by the acquisition of books and journals. The total number of journals received both in physics and mathematics is 190, while the total number of books in the Library is about 8000. About thirty periodicals are received on exchange basis from institutions from various countries like U.S.A., Germany, France, Russia, Japan, Belgium, Brazil. Netherlands etc. The Institute received, preprints of research work done from most of the leading institutions in the world like CERN, Berkeley, Trieste, Saclay, Stanford-etc. In view of the importance of preprints for research in theoretical physics, the Institute has a preprint library for which a separate catalogue is also prepared.

The library issues the following lists for convenience of information

1. List of preprints received in the library (issued fortnightly)
2. List of latest additions (issued monthly)
3. List of periodicals (issued yearly)
4. List of MATSCIENCE reports (issued yearly)
5. List of reprints (issued yearly)

Staff of the Institute

PROFESSOR ALLADI RAMAKRISHNAN :

Director of the Institute
Professor of Theoretical Physics.

B.Sc. (Hons.) (Madras) 1943; Ph.D. (Manchester) 1951; Elected Fellow of the Indian Academy of Sciences, 1955; Visiting member at the Institute for Advanced Study, Princeton 1957-1958; Visiting Professor at the University of Sydney 1954; at the University of Berne 1960, at the International Center for Theoretical Physics, Trieste 1965, 1967, 1968; Professor of Theoretical Physics at the University of Madras till January 1962. Mathematical consultant to Rand Corporation, California, 1962-64.

Editor of the series 'Symposia on Theoretical Physics. and Mathematicis', Plenum Press, New York, U.S.A.

Associate Editor of the 'Journal of Mathematical Analysis and Applications', Academic Press (New York and London).

Executive Editor of the 'I.I.T. Journal of Mathematical and Physical Sciences' (Madras) India.

Has published over a hundred papers on Stochastic processes and elementary partide Physics.

Author of:

1. Elementary Particles and Cosmic Rays-Pergamon Press, 1962.
2. The article entitled 'Probability and Stochastic processes' appeared in Vol. III of Handbuch der Physik, Springer Verlag (1954).

In addition, participated at more than twenty international conferences and lectured at various centers of mathematical sciences in US., Canada, Europe, Japan and Australia, as for example Massachusetts Institute of Technology, Case Institute, Illinois Institute, Naval Research Laboratory, The Boeing and Douglas Research Laboratories and National Bureau of Standards, Washington, the Universities of California at Los Angeles, Berkeley, and Irvine; Stanford, Boston,

Chicago, Brandeis, Maryland, Rochester, Honolulu, Seattle, St.Louis, Buffallo, Milwaukee and Madison (U.S.A.); Oxford, Manchsster, Atomic Energy Establishment Harwell and London (U.K); Marburg Stuttgart, Zurich, Bern, Rome, Naples, Padua, Trieste, Paris, Saclay, Geneva, CERN (Europe); Kyoto, and Tokyo (Japan), Melbourne Canberra and Sydney (Australia) Moscow and Leningrad (U. S. S. R.) and Ottawa, Toronto, Montreal and Vancower (Canada).

Sixteen students have taken Ph. D. under his guidance during the period. 1952 - 1968. Among them are:

Prof. R. Vasudevan, Permanent Member, MATSCIENCE. Prof S. K. Srinivasan, Indian Institute of Technology, Madras. Prof. P. M. Mathews, University of Madras, Madras.

DR. R. VASUDEVAN :

Permanent Member

Faculty of Theoretical Physics

B.Sc. (Hons.) (Madras) 1947; M.Sc. (Madras) 1955; Ph.D. (Madras) 1959; Lecturer in physics in various Government Colleges in Madras. Government service upto 1956; Senior research physicist at University of California, La Jolla, 1959-1961; University of California, Berkeley 1961-1963; Consultant, Rand Corporation, California. 1961-1964; Research Associate, University of California, Berkeley, 1965-1966; Visiting Professor, University of Naples, Italy. 1967-1968.

Member of the Editorial Board of the I.I.T., Journal of the Mathematical and Physical Sciences, (Madras) India.

In addition: participated in international conferences, lectured at various Universities.

DR. K. R. UNNI :

Permanent Member

Faculty of Pure Mathematics.

B.A. (Hons.) (Madras) 1955; M. S. (Utah State University) 1961; Ph.D. (Northwestern University) 1963; Lecturer in Annamalai University, 1955-1959; Assistant Professor, Utah State University, 1963-1964: C.S.I.R. Pool Officer, MATSCIENCE 1965.

Invited participant at the sixth session of the Seminaire de Mathematiques superieures on "Complex Analysis," Universite de Montreal, Canada, 1967.

Reviewer for:

1. Mathematical reviews
2. Zentralblatt for mathematik und ihre Grenzgebiete

Member of the American Mathematical Society, Indian Mathematical Society and Pi Mu Epsilon.

In addition: lectured at various international of Mathematics centers.

DR. N. R. RANGANATHAN :

Associate Member
Faculty of Theoretical Physics

B.Sc. (Hons.) (Madras) 1954; M.Sc. (Madras) 1955; Ph.D. (Madras) 1961; Research Associate, Brandeis University, 1961-1963; Visiting Scientist, University of Naples, Italy, 1965.

DR. K. ANANTHANARAYANAN :

Temporary Member
Faculty of Theoretical Physics

B.Sc. (Madras) 1959; M.Sc. (Madras) 1961; Ph.D. (Madras) 1965; Temporary Member, Matscience, 1965-1966, Research Associate, Stanford University, 1966-1968.

MR. T. S. SANTHANAM :

Temporary Member
Faculty of Theoretical Physics.

B.Sc. (Madras) 1960; M.Sc. (Madras) 1962; Research degree in Theoretical Physics (Trieste, Italy) 1967.

Reviewer for:

Zentralblatt fur Physik.

DR. K. H. MARIWALLA :

Temporary Member
Faculty of Theoretical Physics

B.Sc. (Bombay) 1956; M.Sc. (Bombay) 1958; Ph.D. (Georgia) 1963; Assistant Professor, University of South Carolina, 1963 - 1965; Pool Officer, Indian Institute of Technology, Bombay. 1966-67; and Matscience, 1967.

DR. R. PRATAP :

Temporary Member
Faculty of Theoretical Physics

B.Sc. (Ernakulam) 1942; M.Sc. (Bombay) 1947, Ph.D. (Bombay) 1952; Lecturer in Physics, Siddharth College, 1946 - 1955; A.E.C. Research Fellow, B.E College, Howrah, 1955 - 1956; N.R.C. Fellow, Domihion observatory, Ottawa, Canada, 1956 - 1958; Fellow, Tata Institute of Fundamental Research, Bombay, 1959 - 1965; Bursier at Unsversity Lihre de Bruxelles. Belgium, 1965 - 1967; Research Scientist Associate, University of Texas, Austin, 1967 - 1968.

DR. I. V. V. RAGHAVACHARYULU :

Temporary Member
Faculty of Theoretical Physics.

B.Sc (Hons.) (Andhra) 1954; M.Sc. (Andhra) 1955; D.Sc. (Andhra) 1958; Reader, Annamalai University, 1959 - 1962; Post doctorate Research Fellow, Uppasala University, Sweden, 1962 - 1964; Reader, Annamalai University, 1964 - 1965; Temporary Member, Matscience, 1965 - 1966; Reader, Regional College of Education, Mysore, 1967 - 1968.

PROFESSOR V. V. L. RAO :

Retired Scientist, C.S.I.R. Scheme

B.E. (Elec.) (Madras) 1932; D.I.C. (London) 1937; Fellow IEEE, New York, 1965.

Research Papers

Theoretical Physics

Author(s)	*Title & Journal*
1968	
Alladi Ramakrishnan	Symmetry operations on a hierarchy of matrices, (Jour. Math. Anal. Appl. V. 22, p. 39-42, 1968.)
Alladi Ramakrishnan and I. V. V. Raghavacharyulu	A note on the representations of Dirac groups, (Vol. 8 of Symposia in Theoretical Phys. and Maths. Plenum, 1968)
Alladi Ramakrishnan	On the relationship between the L-matrix hierarchy and Cartan spinors, (Jour. Math. Anal. Appl. V. 22, p. 570-576, 1968.)
Alladi Ramakrishnan, R. Vasudevan N. R. Ranganathan and P. S. Chandrasekaran	A generalization of the L-matrix Hierarchy, (Jour. Math. Anal. Appl. V. 23, p. 10-14. 1968.)
Alladi Ramakrishnan	L-matrices, Quaternions and Propagators, (Jour. Math. Anal. Appl, V. 23, p. 250-253, 1968.)
	A hierarchy of helicity operators in L-matrix theory, (I. I. T. Jour. of Math. and Phys. Sci. Madras, 1968, in press.)
	On the Algebra of L-matrices, (Vol. 9 of Symposia in Theoretical Phys. and Maths. Plenum, in press)
Alladi Ramakrishnan and R. Vasudevan	A hierarchy of idempotent matrices, (Vol. 9 of Symposia in Theoretical Phys. and Maths., Plenum, in press.)

Author(s)	*Title & Journal*
Alladi Ramakrishnan	L-matrices and propagators with imaginary parameters, (Vol. 9 of Symposia in Theoretical Phys. and Maths., Plenum, in press.)
	Generalised helicity matrices, (Jour. Math. Anal. Appl., in press.)
Alladi Ramakrishnan, P. S. Chandrasekaran, T. S. Santhanam and A. Sundaram	Helicity matrices for generalised Clifford algebra, (Jour. Math. Anal. Appl., in press.)
Alladi Ramakrishnan, P. S. Chandrasekaran and T. S. Santhanam	L-matrices and the fundamental theorem of spinor theory, (Vol. 10 of Symposia in Theoretical Phys. and Maths., Plenum, in press.)
Alladi Ramakrishnan, T. S. Santhanam and P. S. Chandrasekaran	On the representations of generalized Clifford algebras, (I. I. T. Jour. of Math. and Phys. Sci. Madras, in press)
Alladi Ramakrishnan, P. S. Chandrasekaran, N. R. Ranganathan, T. S. Santhanam and R. Vasudevan	The generalized Clifford algebra and the unitary group, (Jour. Math. Anal. Appl., in press.)
	Unitary group and the generalized Clifford algebra, (Jour. Math. Anal. Appl., in press.)
	Idempotent matrices from a generalized Clifford algebra, (Jour. Math. Anal. Appl., in press.)
Alladi Ramakrishnan, R. Vasudevan P. S. Chandrasekaran and N. R. Ranganathan	'Kemmer algebra from generalised Clifford elements' (Jour. Math. Anal. Appl., in press.)

Author(s)	*Title & Journal*
Alladi Ramakrishnan	Pageant of modern physics - Planck to Gell-Mann, (C. P. Ramaswamy memorial Volume, in press.)
Alladi Ramakrishnan, R. Vasudevan (with S. K. Srinivasan)	Multiple product densities, (I. I. T. Jour. of Math. and Phys. Sciences, Madras, 1968, in press.)
K. H. Mariwalla	On a definite "parity number" for Fermion, (Nuov. Cim. Serie X, V. 57-A, p. 154-157, 1968.)
T. S. Santhanam	Stueckelberg fields and current algebra, (Nuov. Cim. Serie X, V. 57-A, p. 440-441, 1968.)
S. P. Misra and T. S. Shankara	Semiclassical and quantum descriptions, (Jour. Math. Phys. V. 9, p. 299-304, 1968.)
T. S. Santhanam and P. S. Chandrasekaran	Clifford algebra and massless particles, (Prog. of Theor. Phys., in press.)
R. Vasudevan (with R. E. Bellman and H. Kagiwada and R. E. Kalaba)	Quasilinearization and the estimation of differential operators from Eigenvalues, (SIAM Jour. of Numerical Analysis, V. 2, p. 1, 1968.)
R. Vasudevan	Thermodynamics of Bose gas with negative scattering length (Matscience preprint.)
R. Vasudevan (with S. K. Srinivasan)	Response from non-linear switching elements (To be published in Kybernatic journal.)
R. Vasudevan and V. Radhakrishnan	Thermal conductivity in Shubnikov phase (in preparation.)
R. Vasudevan and T. S. Shankara	Quantum mechanical operators and new phase space distribution (To be published in Nuovo Cimento.)

Author(s)	*Title & Journal*
R. Vasudevan (with A. Coniglio)	Generalized condensation of an interacting Bose gas with pair Hamiltonian (sub. to Nuovo Cimento.)
R. Vasudevan (with G. Idonisi, M. Marinaro)	On the possibility of two stages of phase transition in a non ideal Bose gas (Univ. of Naples preprint.)
R. Vasudevan (with A. De. Deluca, L. M. Ricciardi)	Random matrices of neural networks (Univ. of Naples preprint)
R. Vasudevan (with A. De. Deluca, L. M. Ricciardi)	A note on relating pfaffians (Haffnians) with determinants and permanants (Univ. of Naples preprint)
R. Vasudevan (with A. K. Rajagopal)	Superconducting state in a Homogeneous magnetic field (Sub. to Phys. Rev.)
T. S. Santhanam (with P. Narayanaswamy)	Broken symmetry and Smushkevich principle (To be pub. in Nuovo Cim.)
R. Vasudevan	Photon statistics and coherence in light beams, (Vol. 9 of Symposia in Theoretical Phys. and Maths. Plenum, 1968)
K. H. Mariwalla	Special relativity and faster-than-light particles, (Vol. 10 of Symposia in Theoretical Phys. and Maths. Plenum, 1968, in press)
K. H. Mariwalla and R. Vasudevan	Radiation from an accelerated charge, (Vol. 10 of Symposia in Theoretical Phys. and Maths. Plenum, 1968, in press)
K. H. Mariwalla	Local fields and internal symmetry (To be published)
A. Sundaram	Isobar Photoproduction and vector dominance (Nuov. Cim., V. 58, 905-7 (1968)

Author(s)	*Title & Journal*
A. Sundaram and K. Srinivasa Rao	Regge pole model and U(6, 6) symmetry for $p\bar{p} \longrightarrow \Lambda\bar{\Lambda}$ (Nuov. Cim., in press)
T. S. Santhanam	Generating functions of classical groups and evaluation of partition functions, (Jour. Math. Phys in press)

1962—1967

R. Vasudevan and N. R. Ranganathan	Stochastic problem of electron photon cascades including polarization (Proc. Phys. Soc. (Lond.) V. 76, 650 1960)
R. Vasudevan (with K. Sawada)	Simplified model of liquid Helium (Phys. Rev. V. 124, 2300, 1961)
R. Vasudevan (with L. Nosanow)	Nuclear Paramagnetic susceptibility of the possible low temperature phase of liquid He (Phys. Rev. Letters V. 6, 1-3, 1961)
Alladi Ramakrishnan, T. K. Radha and R. Thunga	The Physical basis of quantum field theory (Jour. Math. Anal. Appl., V. 4, p. 494–526, 1962)
Alladi Ramakrishnan, R. Thunga and T. K. Radha	Possible resonances in Ξ-p reactions (Nucl. Phy. V. 32. p. 517–523, 1962)
G. Bhamathi, S. Indumathi, T. K. Radha and R. Thunga	Pion-production in hyperon-Nucleon collisions (Nuov. Cim. Serie X, V. 24. p. 87–91, 1962)
Alladi Ramakrishnan, T. K. Radha, R. Thunga and A. P. Balachandran	Photo production of pions on Λ. Hyperons (Nuov. Cim. Serie X, V. 25 p. 939–941, 1962)
Alladi Ramakrishnan, T. K. Radha, R. Thunga, and A. P. Balachandran	On the Y*—resonances (Nuov. Cim. Serie X, V. 24, p. 1006–1012, 1962)

Author(s)	*Title & Journal*
Alladi Ramakrishnan and A. P. Balachandran	Partial wave dispersion-relations for Lambda-Nucleon scattering (Nuov. Cim. Serie X, V. 24, p. 980–999, 1962)
Alladi Ramakrishnan, T. K. Radha, R. Thunga and A. P. Balachandran	On the spin and parity of the Y— resonance (Nuov. Cim. Serie X, V. 25, p. 723–729, 1962)
Alladi Ramakrishnan, A. P. Balachandran and K. Raman	Low energy K^+ Nucleon scattering (Nuov. Cim. Serie X, V.24, p. 369-378, 1962)
Alladi Ramakrishnan, T. K. Radha and R. Thunga	On the concept of virtual states (Jour. Math. Anal. Appl., V. 5, p. 225–236, 1962)
Alladi Ramakrishnan, R. Thunga, T. K. Radha G. Bhamathi and S. Indumathi	Dispersion analysis of Ξ production in KN collisions (Nucl. Phys, V. 37, p. 585–593, 1962)
K. Raman	Three particle associated production in pion-nucleon collisions (Nucl. Phy. V. 37, p. 438–448, 1962)
V. Devanathan and G. Ramachandran	Photo-production of charged pions from Nuclei (I) (Nucl. Phys., V. 38, p. 654–660, 1962)
K. Venkatesan and T. S. Santhanam	Some remarks on symmetries shared by strong and weak interactions (Nucl. Phy., V. 45, p. 255–259, 1962)
R. Vasudevan (with I. Soda)	Thermodynamic behaviour of liquid Helium three in its possible superfluid phase (Phys. Rev. V. 125, p. 1484–1493, 1962.)
R. Vasudevan (with Richard Bellman and R. Kalaba)	A note on perturbation series for the periodic solutions of nonlinear differential equations. (Jour. Math. Anal. Appl., V. 4, p. 341–345, 1962.)

Author(s)	*Title & Journal*
Nobuyuki Fukuda	The stability of Hartee-Fock solutions and of collective model (Nucl. Phys., V. 44, p. 553–571, 1963)
G. Ramachandran and V. Devanathan	Nuclear-polarization following photo-production of pions from Nuclei (I) (Nucl. Phys. V. 48, p. 369 – 374, 1963)
K. Venkatesan (with S. K. Srinivasan)	Photo - production of pions from nucleons in the strip approximation (Nuov. Cim. Serie X, V. 30, p. 151-162, 1963)
K. Venkatesan (with S. K. Srinivasan)	The strip-approximation analysis of photo-production of pions on pions (Nuov. Cim. Serie X, V. 30, p. 163-170, 1963)
K. Venkatesan (with S. K. Srinivasan)	Angular momentum analysis of photo-production of pion pairs from a nucleon (Nucl. Phys. V. 48, p. 337-344, 1963)
V. Devanathan and G. Ramachandran	Photo-production of charged pions from nuclei (II) (Nucl. Phys. V. 42, p. 254-263, 1963)
R. Vasudevan (with Richard Bellman and R. Kalaba)	Invariant imbedding and the Tounsend avalanche (Jour. of Math. Anal. and Appl., V. 7, p. 264-270, 1963)
G. Ramachandran and V. Devanathan	Nuclear polarization following photo-production of pions from Nuclei (II) (Nucl. Phys. V. 50, p. 593-598, 1964)
Alladi Ramakrishnan, K. Venkatesan and V. Devanathan	A note on the use of Wick's theorem (Jour. Math. Anal. Appl., V. 8, p. 345-349, 1964)
G. Ramachandran and R. K. Umerjee	Deuteron polarization following neutral pion photo-production (Nucl. Phys. V. 54, p. 665-672, 1964)

Author(s)	*Title & Journal*
V. Devanathan and K. Ananthanarayanan	Photo-production of charged pions from Deuterons (Nuov. Cim. Serie X, V. 32, p. 723-726, 1964)
R. E. Marshak, C. Ryan, T. K. Radha and K. Raman	Universal theory of semi-weak interactions (Nuov. Cim. Serie X, V. 32, p. 408-432, 1964)
K. Raman	Regge poles in weak interactions - I (Nuov. Cim. Serie X, V. 33, p. 545-565, 1964)
G. Ramachandran and K. Ananthanarayanan	Photo-production of pions from H_3 and He (Nucl. Phys. V. 59, p. 633-640, 1964)
Alladi Ramakrishnan, K. Raman and R. K. Umerjee	Isobar production in nucleon-nucleon collisions (Nucl. Phys. V. 60, p. 401-42, 1964)
R. K. Umerjee	Deuteron polarization following elastic scattering of positive pions (Nucl. Phys. V. 60, p. 313-318, 1964)
	Scattering of pions from nuclei (Nucl. Phys. V. 60, p. 497-502, 1964)
Henry P. Stapp	Space, time and elementary particles (Jour. of Sci. & I. R. V. 23, 7, p. 281-284, 1964)
R. Vasudevan (with Richard Bellman and R. Kalaba)	Invariant imbedding theory of neutron transport correlation functions (Jour. Math. Anal. Appl. V. 8, p. 225-231, 1964)
E. C. G. Sudarshan, L. O'Raifeartaigh and T. S. Santhanam	Origin of unitary symmetry and charge conservation in strong interactions (Phys. Rev. V. 136, No. 4b, p. 1092-1096, 1964)

Author(s)	*Title & Journal*
N. R. Ranganathan and T. K. Radha	First Matscience Summer School 1964 (Jour. of Sci. and I. R., V. 24, 1, p. 3-5, 1965)
F. Calogero	Necessary condition for the existence of bound states (Nuov. Cim. V. 36, p. 199-201, 1965)
G. Ramachandran and K. Ananthanarayanan	Scattering of pions from H_3 and He_3 (Nucl. Phys. V. 64 p. 652-656, 1965)
K. Raman	Formalism for parity-nonconserving relations II: Polarization (Nuov. Cim. V. 36, p. 567–585, 1965)
Alladi Ramakrishnan, K. Raman and R. K. Umerjee	Isobar production in Nucleon-Nucleon collisions II: Polarization effects (Nucl. Phys. p. 609–631, 1965)
N. R. Ranganathan and R. Vasudevan	Remarks on Dirac Spurs and Pfaffians (Nuov. Cim. Serie X, V. 37, p. 172-178, 1965)
K. Raman	On scalar $K\pi$ resonances (Nuov. Cim. Serie X, V. 36, p. 115–119, 1965)
	Formalism for parity-nonconserving reaction—I (Nuov. Cim. V. 36, p. 554–568, 1965)
Alladi Ramakrishnan, K. Venkatesan and T. S. Shankara	Sensitivity of the vector coupling constant to Neutrino mass and T-invariance (Nuov. Cim. V. 37, p. 1046–1048, 1965)
K. Ananthanarayanan	Admixture of states in the ground state of ^3He (Phys. Lett., V. 19, p. 43-45, 1965)
Alladi Ramakrishnan, R. Vasudevan (with S. K. Srinivasan)	Some new Mathematical features of cascade theory (Jour. Math. Anal. Appl. V. 11, p. 278–289, 1965.)

Author(s)	*Title & Journal*
R. Vasudevan (with S. K. Srinivasan)	On class of non-Markovian processes associated with correlated pulse trains and their application to Barkhausen noise (Nuov. Cim. Serie X, V. 41, p. 101–112, 1966)
K. Ananthanarayanan	Elastic photo-production of neutral pions from ^{4}He (Nucl. Phys. V. 75, p. 687–690, 1966)
K. Ananthanarayanan and K. Srinivasa Rao	Effects of D-state admixture and hard-core radius on the photo-production of neutral pions from deuterons (Nuov. Cim. Serie X, V. 44, p. 31–38, 1966)
Alladi Ramakrishnan, R. Vasudevan (with S. K. Srinivasan)	Scattering phase shifts in stochastic fields (Zeitschrift fur. phy. V. 196, p. 112–122, 1966)
R. Vasudevan (with S. K. Srinivasan and N. V. Koteswara Rao)	Sequent correlations in stochastic point processes – II (Nuov. Cim. V. 44-A, p. 818–837, 1966)
R. Vasudevan (with A. K. Rajagopal)	Super-conducting state of an electron gas in a homogeneous magnetic field (Phys. Letts. V. 20, p. 585, 1966)
R. Vasudevan (with A. K. Rajagopal)	De Haas-van Alphen oscillations in the critical temperature of type II–superconductors (Phys. Letts. V. 23, p. 539–540, 1966)
R. Vasudevan (with C. C. Sung)	Thermal conductivity due to impurity scattering for superconductors with overlapping bands (Phys. Rev. V. 144, p. 237, 1966)
T. S. Santhanam	Some remarks on the construction of invariants of semi-simple local Lie groups (Jour. Math. Phys. V. 7, p. 1886, 1966)

Author(s)	*Title & Journal*
	P-wave non leptonic decays of Hyperons in SU(6) and representation mixing (Phys. Letts. V. 21, p. 234, 1966)
T. S. Santhanam (with B. Gruber)	SU_3: Compact formula for D (m') x D (m) and for multiplicity M^m (m″) of $m^{E''}$ D(m') (Nuov. Cim. V. 45, p. 1046 1966.)
R. Vasudevan	Theory of general quantum systems interacting with a linear dissipative system (Vol. 2 of Symposia in Theoretical Phys. and Maths., Plenum 1966)
Alladi Ramakrishnan	Some new topological features of Feynman graphs (Jour. Math. Anal. Appl., V. 17, p. 68 – 91, 1967)
	Graphical representation of CPT (Jour. Math. Anal. Appl., V. 17, p. 147-150, 1967)
T. S. Shankara	A Lie algebra of differential forms and quantum mechanics (Nuov. Cim. Serie X, V. 47, p. 552-567, 1967)
R. Vasudevan (with S. K. Srinivasan)	Fluctuation of photoelectron and intensity correlation of light beams (Nuov. Cim. Serie X, V. 47, p. 185-193, 1967)
Alladi Ramakrishnan and I. V. V. Raghavacharyulu	A new combinatorial feature of Feynman graphs (Jour. Math. Anal. Appl., V. 18, p. 117-158, 1967)
T. S. Shankara	A new phase space distribution function (Prog. Theor. Phys. V. 37. p. 1335-1336. 1967)
Alladi Ramakrishnan	A new form for the Feynman propagator (I. I. T., Jour. Math. Phys. Sci. Madras. V. I, No. 2, p. 57-64, 1967)

Author(s)	*Title & Journal*
Alladi Ramakrishnan, R. Vasudevan (with S. K. Srinivasan)	Angular correlation in Brightness of Milky way (I. I. T. Jour of Math. and Phys. Sci. Madras, V. 1, No. 1 & 2, p. 75–84, 1967)
A. Sundaram and R. Sridhar	Regge pole model for A_2 meson production (Nuov. Cim. V. 50, p. 969-971, 1967)
Alladi Ramakrishnan	The Dirac Hamiltonian as a member of a Hierarchy of matrices (Jour. Math. Anal. Appl., V. 20, p. 9-16. 1967)
	Helicity and energy as members of a Hierarchy of Eigenvalues (Jour. Math. Anal. Appl., V. 23, p. 397-401, 1967)
R. Vasudevan with S. K. Srinivasan	Fluctuating density fields (Ann. Inst, Henri Poincare. V. 7, No. 4, p. 303-318, 1967)
R. Vasudevan, K. Venkatesan, and G. Jagannathan	Construction of solvable potentials and some aspects of regularization of singular potentials (Nuov. Cim. Supp. Serie, I, Vol. 5, p. 621–641, 1967)
K. Srinivasa Rao and S. C. K. Nair (with V. Devanathan and M. Rho)	Photoproduction of charged pions from ^{16}O (Nucl. Phys. V. B2, p. 329-341, 1967)
R. Vasudevan, K. Venkatesan and N. R. Ranganathan	A note on some solvable vector potentials for the Dirac equations (I.I.T. Jour. of Math. and Phys. Sci. Madras, V. 1, p. 159-162, 1967)
T. S. Santhanam (with H. Ruegg and W. Ruhl)	The SU(6) models and its relativistic generalizations (Hel. Phys. Acta, V. 40, p. 9-134, 1967)

Author(s)	*Title & Journal*
N. R. Ranganathan (with A. K. Rajagopal and H. Brook)	Magnetic properties of Itinerant electrons: Ferromagnetism (Nuov. Cim. Supp. serie I, V. 5, p. 807-889, 1967)
Alladi Ramakrishnan	Fundamental multiplets (Symp. on Theor. Phys. and Math., Plenum V. 5. p. 85-92, 1967)
Alladi Ramakrishnan	L-matrix Hierarchy and the Higher dimensional Dirac Hamiltonian (I.I.T. Jour. of Math. and Phys. Sci Madras, V. 1, 3, p. 190-193, 1967)
D. Radhakrishnan and T. S. Santhanam	Internal multiplicity structure and Clebsch-Gordon series for the exceptional group G(2) (Jour. Math Phys. V. 8, p. 2206-2209, 1967)
R. Vasudevan (with S. K. Srinivasan)	Stochastic kinetic equations and particle statistics (Sub. to Nuov. Cim.)
R. Vasudevan and K. S. Viswanathan	Effect of paramagnetic impurities in superconductors (To be published)
K. Srinivasa Rao and R. Sridhar (with V. Devanathan)	Photoproduction of charged pions from ^{11}B (Phys. Letts. V. 25B, 456, 1967)

Pure Mathematics

1966-1968

Author(s)	*Title & Journal*
K. R. Unni	Inequalities for weighted entire functions (Tohoku Math. Jour. V. 6, p. 274-282, 1966)
K. R. Unni (with Q. I. Rahman)	Extremal problems and polynomials of least deviation (Scripta Mathe. V. 27, p 303-329, 1966)
K. R. Unni	Certain extremal problems (Vol. 5 of Symposia in Theoretical Phys. and Maths., Plenum 1967)
	Functions of exponential type (Vol. 6 of Symposia in Theoretical Phys. and Maths., Plenum 1968)
Y. Sitaraman	Tauberian theorems for infinite logarithmic summability (L) (Monatschefte fur Mathe. 1966)
	A high indices theorem for $(A\ \alpha, \gamma)$ summability (Math. Zeitschrift, 1966)
H. S. Shapiro	Generalized analytic continuation. (Vol. 9 of Symposia in Theoretical Phys. and Maths. Plenum, 1968)
	Smoothness of the boundary function of a Holomorphic function of bounded type. (Arkiv for Matematik, 1968)
P. K. Geetha	On Bernstein approximation problem (Jour. Math. Anal. Appl. in press)
N. R. Nandakumar	A note on derivation pairs (To appear in Proc. Am. Math. Soc.)

List of Matscience Reports

Report No.	*Author(s)*	*Title*
1.	—	Proceedings of the First Anniversary Symposium — The resonant states of elementary particles.
2	G. Ramachandran	Lectures on Angular Momentum.
3	A. P. Balachandran	Lecture course on introduction to complex variable theory.
4	S. Swaminathan and R. Venkataraman	Lecture on group theory.
5	Thunga Satyapal	Collected topics in Elementary particle theory.
6	T. K. Radha and K. Venkatesan	Lectures on Mandelstam representations.
7	Einar Hille	Lectures on differential equations.
8	K. Raman	Lectures on an introduction to complex angular momentum, Regge Poles and High energy scattering.
9	L. I. Schiff	Lectures on Gravitation.
10	R. E. Marshak	Lectures on Weak Interactions.
11	E. C. G. Sudarshan	Lectures on Foundations of quantum mechanics and field theory.
12	K. V. Krishnamurthy	Notes on Elementary particle transfer processes in Solution chemistry-Electron transfer reactions.
13	A. T. Bharucha-Reid	Notes on Banach spaces, Basic definitions and theorems and related topics.
14	S. Kamefuchi	Lectures on the Stueckelberg formalism of vector meson fields.
15	Thunga Satyapal and K. Venkatesan	Lectures on Quantum electrodynamics.
16	Peter Durr	Lectures on the non-linear spinor theory of elementary particles.

17	K. Venkatesan	Report on recent experimental data (1963).
18	—	Collected seminar lectures on Elementary particles.
19	M. H. Stone	Functional Analysis.
20	P. Roman	Lecture on an introduction to dispersion relation techniques.
21	—	Proceedings of the Second Anniversary Symposium (January, 1964).
22	R. Hagedorn	Lectures on the relativistic kinematics and polarization.
23	M. Jacob	Lectures on the theory of strong interactions.
24	S. Kamefuchi	Lectures on parastatistics.
25	L. O'Raifeartaigh	Lectures on local lie groups and their representations.
26	Henry P. Stapp	Lectures on analytic S-matrix theory.
27	E. Yamada	Lectures on broken symmetry and Goldstone Boson.
28	B. Zumino	Lectures on magnetic properties of a superconductor.
29	F. Mohling	Introduction to quantum statistical mechanics of degenerate Bose systems.
30	A. T. Bharucha-Reid	Lectures on semi-group of operators.
31	A. T. Bharucha-Reid	Lectures on theory of random equations.
32	B. Zumino	Lectures on guage invariance and mass of vector Bosons.
33	E. C. G. Sudarshan	Lectures on origin of symmetries.
34	Jerzy Lukierski	Lectures on gauge transformations in quantum field theory.
35	K. Symanzik	Lectures on a modified model of Euclidean quantum field theory.
36	K. Venkatesan	Report on Recent Experimental Data (1964).
37	A. Fujii	Lectures on Fermi dynamics.

38	M. Gourdin	A mathematical introduction to unitary symmetries.
39	J. V. Narlikar	Theories of gravitation.
40	K. Venkatesan	Report on Recent Experimental Data (1965).
41	K. R. Unni	Introduction to Hilbert Space.
42	L. Rosenfeld	Theory of nuclear reactions.
43	K. R. Unni	Concepts in modern mathematics I (Algebra).
44	H. Ruegg	Lectures on Relativistic Generalization of SU(6)
45	W. K. Hayman	Lectures on transfinite diameter and its applications.
46	Ph. Meyer	Selected topics in weak interactions.
47	J. Rzewuski	Lectures on Functional formulation in S-Matrix theory.
48	Pl. Kannappan	Theory of functional equations.
49	P. C. Vaidya	Selected topics in Gravitation.
50	K. Venkatesan	Report on recent experimental data (1966).
51	K. R. Unni	Concepts in modern mathematics II (Topology).
52	K. R. Unni	Concepts in modern mathematics III (Analysis).
53	V. Krishnamurthy	Duality Theory in locally convex spaces.
54	J. H. Williamson	Representation theory for Banach algebra and locally compact groups.
55	H. S. Shapiro	Smoothing and approximation of functions.
56	D. Gaier	Complex variable proofs of Tauberian theorems.

57	K. Srinivasa Rao and R. Sridhar	Nuclear models and Nuclear matter.
58	V. V. L. Rao	International system of units.
59	D. A. Dubin	Relativistic physics in one space and one time dimension.
60	R. Vasudevan	Coherence phenomena in quantum me chanical systems.
61	T. S. Santhanam	Group theory and unitary symmetry.
62	R. H. Good	Description of particles with any spin and with internal symmetry.
63	B. Gruber	Topological groups and global properties.
64	W. H. J. Fuchs	Meromorphic functions of lower order less than one.
65	K. Venkatesan	Report on recent experimental data (1967).

The Theoretical Physics Seminar
1959 - 1961

The Theoretical Physics Seminar was a private association of scientists formed in April 1959 with about fifteen members who were associated in their academic work with Professor Alladi Ramakrishnan. The seminars on various topics in modern physics were held at his residence and this group formed the nucleus of the Institute sponsored directly by the Government of Madras and now supported also by the Government of India. The following were the visitors to this Theoretical Physics Group :

Name	*Particulars*
Prof. P. A. M. Dirac, F.R.S., N.L. England	Lucasian Professor, Cambridge
Prof. M. Oliphant, F.R.S.	Australian National University, Canberra
Prof. Cherry, F.R.S.	University of Melbourne, Australia
Prof. H. Messel	Nuclear Science Foundation, University of Sydney Australia
Prof. W. W. Buechner	M. I. T., U.S.A.
Prof. T. G. Room, F.R.S.	University of Sydney, Australia
Prof. L. Schwartz	University of Paris, France
Prof. H. Pitt, F.R.S.	University of Leeds, England
Sir C. G. Darwin, F.R.S.	Former President, Royal Society, England
Prof. L. Janossy	Director, Eotvos Institute, Budapest, Hungary
Dr. T. Kotani	University of Tokyo, Japan
Prof. S. Koba	Yukawa Hall, Kyoto, Japan
Prof. Andre Mercier	University of Berne, Switzerland
Prof. N. Dallaporta	University of Padova, Italy
Prof. A. M. Lane	A. E. Research Establishment Harwell, England

Prof. George Gamow	University of Colarado, U.S.A.
Prof. Niels Bohr, N. L.	Bohr's Institute of Theoretical Physics, Copenhagen
Prof. Abdus Salam F.R.S.	Imperial College, London, England
Prof. Christoff	University of Sofia, Bulgaria
Prof. Philip Morrison	Cornell University, N.Y., U.S A.
Prof. A. H. Copeland	University of Michigan, U.S.A.
Prof. Kamp-de-Feriet	University of Lille, France
Prof. M. H. Stone	Distinguished Service Professor, University of Chicago, U.S.A.
Prof. Hlavaty	Institute of fluid dynamics,Indiana, U.S.A.
Prof. W. Heitler, F.R.S.	University of Zurich, Switzerland
Prof. M. Gell-mann	Caltech, U.S.A.
Prof. R. A. Dalitz	University of Chicago, U.S.A.
Prof. Sandstrom	Uppsala University, Sweden
Prof. D. Glaser, N. L.	University of California, Berkeley, California, U.S.A.
Dr. M. M. Shapiro	U. S. Naval Res. Lab., Washington, U.S.A.
Prof. S. Chandrasekar	Distinguished Service Professor, University of Chicago
Prof. Manoj K. Banerjee	Saha Institute of Nuclear Physics, Calcutta
Prof. M. J. Lighthill	Director, Royal Aircraft Establishment Farnborough, U.K.
Prof. McCrea Hazlett	Vice President, University of Rochester, U.S.A.

PROCEEDINGS OF THE INAUGURATION OF THE INSTITUTE OF MATHEMATICAL SCIENCES

ON

3RD JANUARY 1962

Messages and Greetings

The Institute was inaugurated on January 3, 1962 by Professor S. Chandrasekhar, Distinguished Service Professor of Theoretical Astrophysics at the University of Chicago. The faith of the sponsors in international goodwill and support for the Institute was amply justified by the flood of greetings 'from California in the west to Sydney in the east' on the eve of the inauguration. The message from Professor Niels Bohr, the father of modern physics was characteristic of his boundless generosity and his particular concern in the advancement of science in India.

The following cable was received just an hour before the Inauguration on 3rd January 1962 :—

> "At inauguration of the Institute of Mathematical Sciences in Madras the whole group of the Copenhagen Institute for Theoretical Physics wants to send its heartiest felicitations. The community of physicists has been impressed by the vigour and zeal with which Prof. Ramakrishnan has been able to educate and inspire his young pupils and collaborators and the work in the new Institute will be followed with keen expectations. Indeed as an important asset to scientific research in India the creation of the Madras Institute is eagerly welcomed in that worldwide co-operation in science which offers so great opportunities for promoting the understanding between all peoples."
>
> —Niels Bohr, Copenhagen.

INTRODUCTORY ADDRESS

GIVEN BY

Professor ALLADI RAMAKRISHNAN

So the miracle has happened. By the Grace of God and the will of man, a new situation has been brought into being which augurs to be the starting point of an intellectual renaissance, the nature and magnitude of which cannot be foreseen at the present time. It is incredible that a series of events, each as improbable as the other, should have taken place in such steady and rapid succession. It is as though a chapter of a book of fairy tales has been transmuted into real life and I feel like one who wakes up from a dream to find reality stranger than fantasy.

That dream is so chaste that I have the courage to ask all those present here to share it with me. It originated five years ago in the exotic atmosphere of the quaint old town of Kyoto in Japan where I spent six weeks at the invitation of Professor Yukawa. In the 'domestic' environment of the Yukawa Hall, young Japanese physicists, the hope and pride of their country, just resurrected from the second world war, gathered together in enlightened leisure to discuss the most abstruse problems of modern physics. That strange enchantment drew me into the domain of elementary particle physics and I played with the idea of creating something like the Yukawa Hall in my own home town where my great father had made his legendary reputation in another field of intellectual activity.

This enchantment became a passion when a fortuitous circumstance took me to the new world and I had the opportunity to attend the Conference on High Energy Physics at the University of Rochester in the spring of 1956. Within four days I was brought face to face with the rising generation of American physicists. One had only to listen to Gell-Mann and Chew, Feynman and Goldberger to realise that a new era in American physics has been ushered in. American institutions no longer depended on the guidance of European scientists as they did a decade ago, when due to the chance of war, they

were able to offer hospitality to European physicists like Fermi, Segre and Bethe. American physics leapt from infancy to manhood within this decade and it has now become almost a necessity for European physicists to spend some time in the great American institutions and in the laboratories where things are happening every day and every hour. I felt that such a transformation must needs come in my own country which despite its organised efforts in scientific research has yet to take its place in creative science.

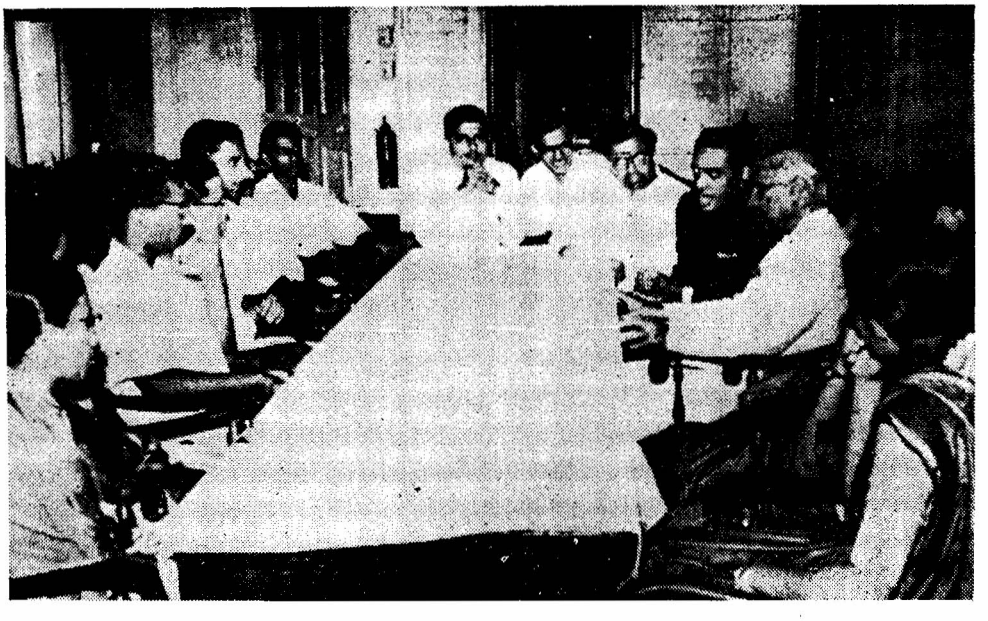
I therefore tried to analyse the causes for our failure. There has always been the conventional argument that there was not enough talent in the country, which is not borne out by facts. It is a tragedy too deep for tears that we do not take any cognisance of talent or creative work unless it has received recognition outside our frontiers. Sometimes, the wait is too long, the response so cold that it freezes up the all too frail impulses for academic life in our country. What we need is a new generation of scientists impatient for opportunities, intolerant of mediocrity, full of action, full of manly pride and friendship like their compeers in the new world, who have not only faith in their powers, but in the scientific progress of their country.

I was strengthened in this faith during my stay, at the kind invitation of Professor Oppenheimer, in Princeton where the most gifted minds in mathematical sciences gather together every year in an atmosphere exhilarating for creative work. It was the momentous year when the work of Yang and Lee marked the greatest advance in physical thought since the birth of quantum mechanics in 1926. I held a watching brief as a representative of our unborn Institute and I returned from Princeton with no other thought dominating my mind except to reproduce in a small measure at least the atmosphere for such creative work. Chance and circumstance came to my favour when a small band of students, stricken by the same splendid sickness, gathered round me in goodly friendship. We had no resource at our command except the love of common excitement for doing something new. To this fraternity we gave a local habitation and a name—" Theoretical Physics Seminar " It was located in my family home with the consent of my

'His benign interest in the work of our group was the immediate stimulus for the creation of the Institute'

Professor Niels Bohr Nobel Laureate, with Prof. Alladi Ramakrishnan (1961 January)

'The impression they made on our Prime Minister was more due to his generosity.....'



Prime Minister Jawaharlal Nehru conversing with Prof. Alladi Ramakrishnan and members of the Theoretical Physics Seminar

gracious wife. We met in leisured comfort and indulged in the impertinence of attempting to work on the same type of problems as are engaging the attention of theoretical physicists elsewhere. We were encouraged in our efforts by the frequent visits of famous physicists whose friendliness and co-operation were our only sources of strength and sustenance. What a fine hour it was when Bohr and Salam who span the growth of modern physics from atomic physics to gauge theories of elementary particles, evinced an interest which gave us the strength to hope when we were all alone and everything seemed so near despair. We waited and watched for something to happen.

It was one of the fortunate moments of my life when I met the Finance Minister one evening at a gathering of international students. It puzzled me beyond comprehension to find the Minister, who must be more concerned with building dams and bridges, getting interested in the development of mathematical research. I felt a trifle guilty that I had inveigled him into this domain which has intoxicated me and my associates beyond reason. Soon I realised that it became almost a faith with him, a faith which was strengthened by his recent visit to the United States. He returned with the conviction that creative science needed the noble heat of youthful ambition and not the tepid caution of unfeeling mediocrity. Before proceeding to take steps for the creation of an Institute for Advanced Learning he was anxious to have the blessings and active support of our Prime Minister. It occurred to him in a discussion with my esteemed and genial friend Dr. M. M. Shapiro that all the students associated with me should be introduced to the Prime Minister during his visit to Madras. The impression they have made on our Prime Minister was more due to his generosity than to their own achievements. It was his wide humanity and deep concern for the prosperity of our country that made him see the light of hope even in the feeble efforts of smaller men. His support, by agreeing to be our Patron, gave that final impulse whcih resulted in the setting up of this Institute.

The final act in this strange dream is even more fantastic than the events that preceded it. I approached Professor S. Chandrasekhar, one of the greatest astrophysicists of our time,

who stands so high above the rest of our own common mould, wtih a request that he should associate himself with the new Institute. It was in a sense an insolence on my part to do so when I was assuming the Directorship of the Institute. I suppose you will excuse me for this if I assure you that the spirit in which I did so was animated by that in the greatest of legends when Arjuna approached Lord Krishna for his support. It was accepted with the same legendary grace, and the Institute has honoured itself by his association with it. This band of students, the firstlings of the fold, must consider themselves to be the happy few to have chosen him as their guide.

This, then, is the genesis of this new Institute which symbolises the hopes and ideals of the entire scientific community in India. The Government of Madras and in particular our Chief and Finance Ministers ably assisted by the Education Secretary, another victim of the splendid sickness, must be congratulated for the most gracious gesture that has ever been made by any administrative authority to the academic community in our country. The best tribute we can pay to our government is to say, "it does not seem to be the red tape—it is the blue riband." Is it not natural that greetings have poured from scientists all over the world, from California in the west to Sydney in the east? To those scientists who visited Madras, whose very presence had introduced the heady atmosphere of Berkeley into the placid environs of my family home, we are deeply grateful, for they kept alive the state of hope till the moment of its realisation. As for myself it is a period of thanksgiving particularly to my great teachers Professor Bhabha and Professor Bartlett who initiated me into theoretical physics. My only regret is that my parents whose home nursed the happy breed, are not alive today at the crucial moment of my academic life. In recompense I shall pass on to my students their message that the pursuit il learning is at its best when it is part of a way of life. That is the ideal to which this institute is dedicated.

PRESIDENTIAL SPEECH

BY

MR. C. SUBRAMANIAM

I am particularly happy to be associated with this inaugural function. I am happy that I have played some part in bringing this Institute into existence.

I do recall my meeting with Professor Alladi Ramakrishnan at a function where he mentioned to me that an institute of this sort should be started in Madras. I immediately agreed to work upon it. About eighteen months ago, I wrote a letter to the Prime Minister requesting him to take some interest in the proposal and enable us to start this institution. But, unfortunately, something or other was happening and it was getting postponed from time to time. I also wrote to the chairman of the University Grants Commission and to Dr. Bhabha to give us their blessings. But, to my regret I found encouragement was lacking. Even though I happened to be a humble student of science of this College, still since I happen to be a politician, I wanted to be rather cautious in taking any step in the matter, because I might be accused of interfering with the academic activities of the University.

Ultimately, when the Prime Minister visited Madras recently, I suggested that he should meet this band of young students —young men and women—who were working under Professor Alladi Ramakrishnan. He immediately agreed and he had a pleasant half-hour with the boys and girls who assembled at Raj Bhavan to meet him.

In fact, after that meeting he said "I feel humble before you (students) because you are all so intelligent in the field of science." This gave further encouragement to me and I took further steps to see that the Institute was started as early as possible.

It is indeed a novel thing that the Institute should be started apart from the university. But, it was the right step; particularly

in the field of science, we cannot afford to follow conventional steps. Perhaps unconventional methods have produced better results in science. With his usual common sense, the Chief Minister also approved the idea. The Prime Minister was then approached to become the Patron of the Institute. It was the day on which the Goa action was being taken when we discussed this and the Prime Minister gave his consent to be the patron of the Institute. The starting of the Institute was therefore possible mainly because of the support given by the Prime Minister. He was good enough to mention the subject to the UGC Chairman, Dr. Bhabha, and others. It was after this that this humble effort of ours got the blessings of everyone who matters in the field of scientific work.

When Prof. Chandrasekhar was in the Physics Hons. class, I was studying the pass course in Physics. Even then, he was a very distinguished student, recognised by the scientific world as a promising young man. He has overfulfilled those expectations. We are happy that he has attained such high eminence, Prof. Chandrasekhar has agreed to be a Honorary Professor of this Institute and also to associate himself with the activities of the Institute whenever he visits India. I am sure that by this association the Institute has been put on a sure footing and has immediately gained world-wide recognition.

Prof. Ramakrishnan himself is a well known figure in the scientific world. Perhaps by his taking up the directorship, the Institute has gained a status in the scientific world; but with Prof. Chandrasekhar's association, I think, the future of the Institute is guaranteed.

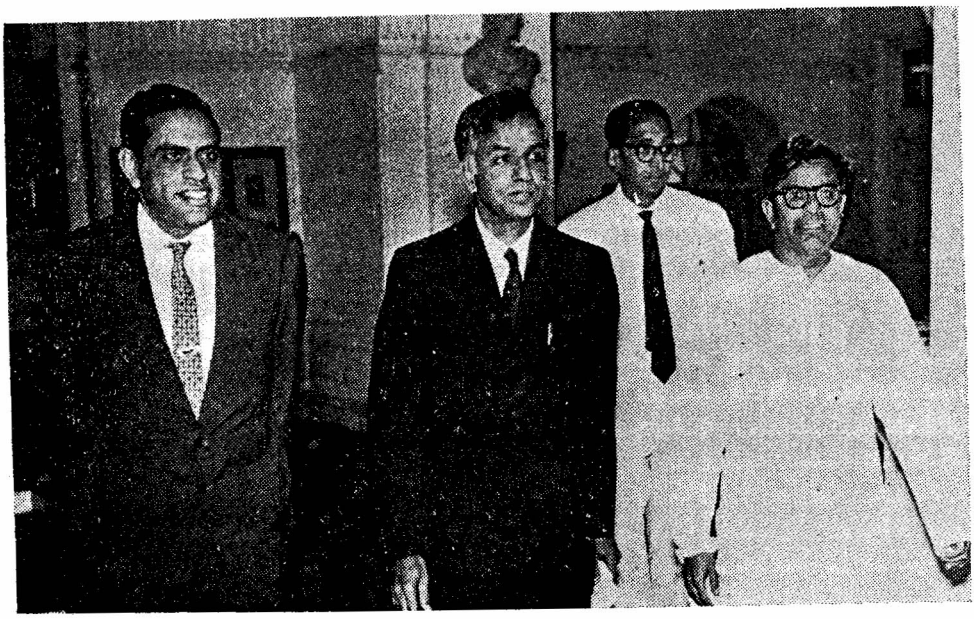
Prof. Ramakrishnan said the miracle has happened. I will say this is the beginning of the miracle. The justification for the Institute will be in the results to be achieved, when the miracle will really happen. Having known Prof. Ramakrishnan and the band of young men and women working under him, I have no doubt that ere long this Institute will be one of the well-recognised science institutions in the whole world. In the field of scientific research, we cannot anticipate—anything might happen or might not happen. The chances are there for great discoveries and work of international repute. Out of the

young men and women, I hope a few will earn the Nobel prize of Physics.

I know there were some doubting Thomases with regard to the steps we have taken in starting the Institute, But I have no doubt in my mind that this is just the correct thing to do. For, our young men and women should have full opportunities to do research. During my visit to the United States, I came across many of the Indians—young men and women – working there. The Professors were all praise for the work they were doing. I thought these young men and women have to come away from our country because opportunities were not made available to them in our own country.Professor Chandrasekhar himself is a classic instance where we have lost—I will not say we have lost—he had to go away to another country to establish himself as a great scientist. If only he had continued his work here and brought fame to the Madras University and not to the Chicago University! I hope he will come to Madras when this Institute becomes successful. I hope this Institute will justify itself and then it will not require any politician or administrator to give it strength; on the other hand, it will give strength to the politician and administrator.

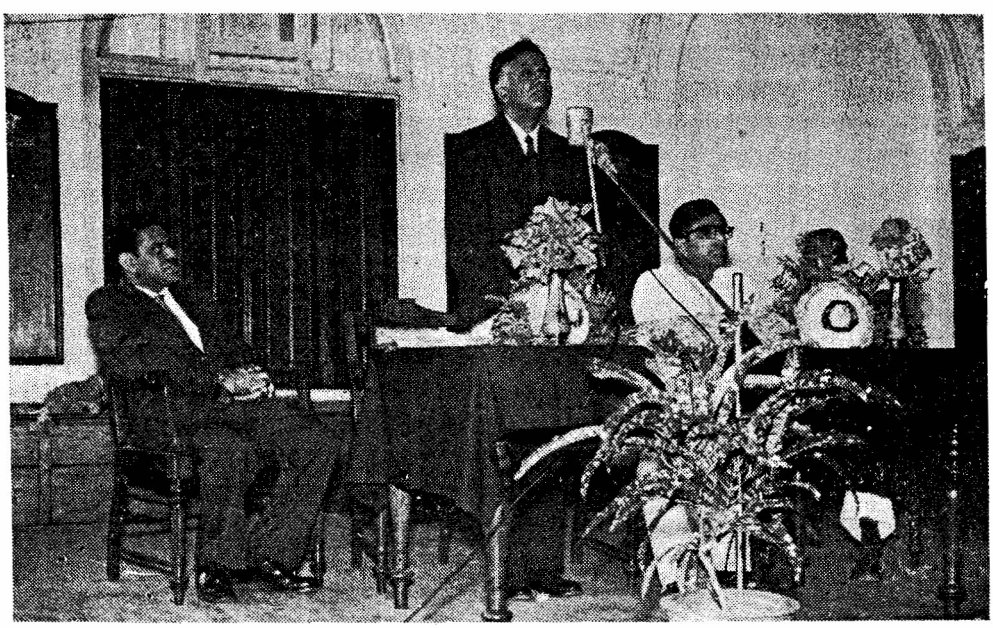
"I now request Professor Chandrasekhar to inaugurate the Institute."

'The spirit in which I approached Prof. S. Chandrasekhar was animated by that in the greatest of legends when Arjuna approached Lord Krishna for his support'



Prof. S. Chandrasekhar with Mr. C. Subramaniam and the Director

"Of course the name of Ramanujam comes to the mind of everyone. He is, in my opinion without question the greatest man of science India has produced in recent times"



Prof. S. Chandrasekhar delivering the Inaugural Address on January 3, 1962

INAUGURAL ADDRESS

BY

PROFESSOR S. CHANDRASEKHAR

Professor Chandrasekhar said that the establishment of the Institute by the Government of Madras was an event which was unique in many ways. If one looked at the scientific scene in India, then the greatest impression was made by the development of the various national laboratories which were devoted to various aspects of applied sciences and in some instances even to provide the base for special industrial advancement. During his recent visit to these laboratories he gathered the impression that in them a determination and purposefulness in their work prevailed. He said this determination and purposefulness was a consequence of the determination and purposefulness with which the Government of India had been pursuing industrial development of the country since Independence.

"On the other hand, if one compares the record of Indian science during this same decade, I am afraid the comparison is not only disappointing, it is even discouraging. In saying this, I do not wish to deprecate in any way the very important work which groups and individuals are doing in their respective fields all over India. But among these groups and individuals I find very often a sense of frustration and constant irritation derived from it. My feeling is that this frustration and disappointment among the men and women devoting themselves to pure sciences is largely due to the lack of appreciation and understanding of their efforts both at the Governmental and University levels.

Illustrating this lack of appreciation, he said, in most centres of learning even the head of the department could not sign a requisition exceeding Rs. 12–50. He pointed out that in America even a janitor or cleaning woman could make a requisition for amounts exceeding ten times this without any formal approval. It was quite important that the efforts of the pure scientist should be free from small administrative difficulties of this kind.

Professor Chandrasekhar said there was no real dichotomy between pure and applied sciences. On the contrary, they were very closely related. Many of the spectacular advances of modern living such as radio, television, air transport, atomic reactors had all resulted from specific results derived from the pure sciences, "efforts devoted primarily to our understanding of our physical environment."

So also, many of the advances in pure sciences, particularly in physical and biological sciences, had resulted from advances in applied and technical sciences. There should therefore be no misunderstanding that he attached more importance to the one or the other. "The important thing is that science is an entire whole and the different aspects of it are equally essential." In a country like India where industrial advancement was essential, it was perhaps easy to appreciate the importance of applied sciences. But in the long run, he said, the lack of corresponding encouragement and support for the efforts of the pure scientist was likely to result in serious harm. From this point of view, it was a great thing that the Government of Madras should have set up the Institute of Mathematical Sciences, devoted to research in theoretical physics, and applied mathematics.

The establishment of the Institute was therefore welcome not only in the sense that every new venture in learning was to be welcomed but also because it represents a new departure in the current scientific scene. He hoped this "most wholesome development" would be extended to other fields of science like the biological sciences and also emulated by other States.

It was appropriate that the Institute was located in Madras because the record of India in the mathematical sciences has largely been written by men who come from this area of the country.

"Of course, the name of Ramanujan comes to the mind of everyone. He is, in my opinion, without question the greatest man of science India has produced in recent times. But Ramanujan was nourished during his precious six years in Cambridge. I feel it is a matter of regret that there is still no adequate memorial to Ramanujan in India."

The Professor said there were other names also to be mentioned in this connection such as Mr. R. Vaidyanathaswami, Mr. T. Vijayaraghavan and Mr. S. Sivasankaranarayana Pillai. But all these men did not find that adequate support and encouragement which their measure of achievement would have merited.

He learnt that the Institute would be so organised that it would not suffer from the "hierarchical disease" the presence of which in centres of learning was most harmful.

He was happy that the Institute would be organised in such a way that the kind of atmosphere, needed for those devoted to research, would be obtained here.

With these words Professor Chandrasekhar declared the Institute open.

APPENDICES

That Magic Moment

The world is so worshipful of greatness that we rarely wait to think of its true source, strength and sustenance. It lies in the manner in which it touches the individual lives of those who feel the depth and extent of its influence. Such is the quality of the greatness of our beloved Prime Minister whose life has almost directed our way of life.

It was in 1947, during the eventful day of the Constituent assembly that I had the privilege of feeling his benign presence and watching that handsome face with pleasure and wonder. Even my great father who was entrusted with the task of drafting our constitution could not hold his attention, for the distant look in his eyes seemed to peer into the uncharted future and was oblivious of the immediate environment. It was unbelievable that an occasion would arise fifteen years later when by a fortuitous circumstance, I would be called upon to place before him, in person, a proposal which is to affect the lives of young scientists in the years to come. I cherish that moment with blatant delight and the best homage I can pay to so noble a soul is to transmit the magic of that momentous interview to my fellow scientists. To estimate the significance of that event I have to describe the background against which it took place.

Ever since the war, there was so much discussion about the migration of Indian scientists abroad and the difficult conditions that inhibited the growth of creative work in India. This looked paradoxical, particularly when the same period saw the establishment of various Governmental organisations to stimulate and support scientific research. While there was basic agreement among the academic community and the organisers of scientific endeavour that something should be done to vivify and vitalise the atmosphere, there was considerable conflict of opinion as to how this could be done. Of course, there was the very conventional view that higher learning should be pursued in the universities since creative work could only be sustained in consonance with a teaching programme. On the other hand, the need for specialised

institutes and laboratories was too obvious since the financial resources available had to be conserved and their magnitude demanded direct support from the Central Government.

The mathematical sciences demanded a combination of these two modes of organisation. It is too well-known that the advances in physics in the last decade were comparable with the progress in physical sciences over century before, for, with the development of giant accelerators and new experimental techniques, the physicist became aware of new particles and new phenomena associated with them, not anticipated even by the creators of quantum mechanics and relativity.

The American Universities, true to the pioneering traditions of that great nation, adjusted themselves to the rapid changes in the scientific scene by creating semi-autonomous and highly specialised institutions within their expanding framework. Unfortunately, nothing like this had happened in India or was likely to happen, in view of the repeated emphasis on insurmountable difficulties and too firmly established conventions. A break-through was necessary and therefore it was suggested that an autonomous institution should be created and supported by the Government but which would actively collaborate in academic work with the Universities. It was a miraculous sequence of events that culminated in the decision of our then Finance Minister of the Government of Madras, Mr. C. Subramaniam, to create an institute of this kind. Even 'this man of steel' required the support and assent of our Prime Minister since this idea was considered almost revolutionary in the domain of our scientific education. To whom else could we submit such a proposal than to one who had effected the greatest revolution in our minds—the desire for a free and independent India which was achieved within his own life-time?

Indeed this suggestion of consulting the Prime Minister was put forward by an American physicist, Dr. M. M. Shapiro who visited Madras as a guest of the theoretical physics group here. In the course of a casual conversation when the Finance Minister complained of various difficulties and obstacles, the professor interposed and said, "Why not let the Prime Minister see the members of the theoretical physics group during his visit to Madras and find out his reactions?"

In spite of a crowded series of official engagements for the Prime Minister, it was found possible by the Hon'ble Subramaniam to arrange an interview at the Raj Bhavan at 9-30 p.m. after an official dinner, to which my wife and I were invited to have a preliminary occasion to meet the Prime Minister. I need hardly describe my trepidation and anxiety, for so much was to depend upon a few minutes' conversation — almost the dreams and aspirations of a whole scientific community hung on the smiling lips of our Prime Minister. Ten minutes before the close of the dinner, he summoned me and all the students gathered to have a personal interview with him. It was strange feeling for me to do all the talking with a man who held almost unquestioned sway over the destinies of our country. At the end he asked me only one question: "Are you really convinced that we should have an Institute of the kind you are insisting upon?" I naturally said 'yes' with all the emphasis at my command and he just smiled.

Two months later, the Finance Minister decided to obtain the formal assent of the Prime Minister. We waited with bated breath at the Madras airport as Mr. Subramaniam came across the tarmac and said with his inevitable smile. "He is going to be our patron." Later on, he recounted to us what a miracle it was to succeed in directing the attention of the Prime Minister to this question. It was the day on which the decision for military action in Goa was being taken that the Prime Minister agreed to be the patron of the Institute.

Sixteen months later, I met him again to report on the progress of the Institute. He just asked, "Do you want anything particular to be done now?" It was too valuable an opportunity to miss and I stressed the need for extending the visiting programme to young post-doctoral workers of outstanding promise. Through his aegis has now been set in motion an international collaboration in science which in the words of Niels Bohr, "offers so great opportunities for understanding among the peoples of the world"—a cause nearest to Nehru's mind and heart.

The triumph of Nehru's life is the triumph of imagination over prejudice and ignorance—the characteristic feature of all scientific endeavour. To this ideal, aspirant members of the Indian scientific community should dedicate themselves.

ALLADI RAMAKRISHNAN

Jawaharlal Nehru

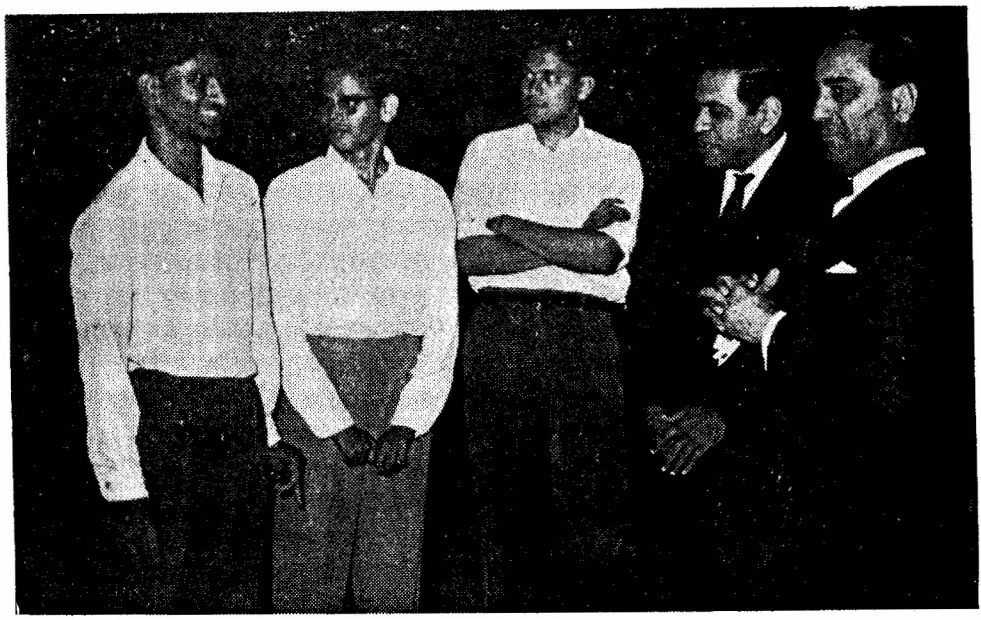
"Few lives in the history of mankind have shone with such many-splendoured hues. Born to wealth and prosperity he became the idol of peasant India, its hope and its redeemer. Educated in the most exclusive of English institutions he stood against the might of the British Empire with dauntless courage and in open defiance. He emerged a victor after decades of travail and remained the staunchest friend of England, its people and its gracious Queen. As the architect of a new republic he designed it within the stable structure of the great commonwealth. Rational in his beliefs to the limit of secularism, he wore the mantle of Gandhi, the man of God, with grace and dignity. He had irrepressible faith in a socialistic economy but his very name is synonymous with the freedom of the human spirit. His patriotism was a flaming passion which burnt out the vestiges of foreign rule from our sacred land; yet he was true citizen of the world that his counsels were sought in the United Nations. An individualist in thought, he loved people to an extent that every child looked to him as a father and every Indian felt his benign influence. His princely graces set him apart from our too common mould but he was the darling of modern India, and there is no single home from the southern Cape to the Himalayan heights where the very mention of his name did not inspire love and affection.

The best years of his youth were spent in isolation behind prison bars; but that was the period he wrote his dearest letters, transmitted the warmest feelings and nourished the most sanguine hopes. Those years left no wrinkle on that handsome brow which age could not wither nor anxieties strain.

His life was dedicated to improving the standard of life of the common man; but he remained a restless intellectual, a votary for the advancement of science in our country. Amidst the tumult of politics and the anxieties of administration, he found time to exhort scientists to greater achievement and the aspirant youth to the pursuit of knowledge."

ALLADI RAMAKRISHNAN

"The legacy of Bhabha is the desire for excellence in the mathematical and physical sciences and more generally in the fascinating endeavour of understanding nature"



Professor H. J. Bhabha, Chairman, Atomic Energy Commission (India) and Member, Board of Governors, Matscience, talking to students

Mr. M. S. Adiseshiah, Director General of UNESCO discussing with Prof. L. A. Rubel, visiting scientist and the director

H. J. Bhabha

"He was born to be a theoretical physicist of worldwide reputation. He sought and grasped opportunities with undiminished vigour and uninterrupted success characteristic of a man destined to fame and fortune. A true product of this triumphant era of modern science, his early association was with the great masters—Pauli in Zurich, Dirac in Cambridge, Bohr at Copenhagen and Kramers in Holland. He entered the Indian scientific scene in his early thirties, fresh from his laurels after the formulation of the cascade theory and the award of the fellowship of the Royal Society. Every scientist in India who had the slightest contact with or feeling for modern physics, knew that something miraculous was going to happen from the small beginnings of the cosmic ray research unit under Dr. Bhabha in the Indian Institute of Science. They had not to wait too long to see the gigantic edifice of the Tata Institute of Fundamental Research rise overlooking the lapping waters of the Arabian Sea. What is more, this ancient land where methods of agriculture have not changed since the dawn of civilisation, under his leadership joined the worldwide effort for harnessing atomic energy for peaceful puposes. This revolution in thought and in deed is bound to alter the course of the economic development of this country of teeming millions

This movement has the specific consequence that the pursuit of science, instead of being confined to the ivory tower, has now become a profession, the achievements of which will affect the daily lives of our people.

The legacy of Bhabha is the desire for excellence in the Mathematical and physical sciences and more generally in the facinating endeavour of understanding nature."

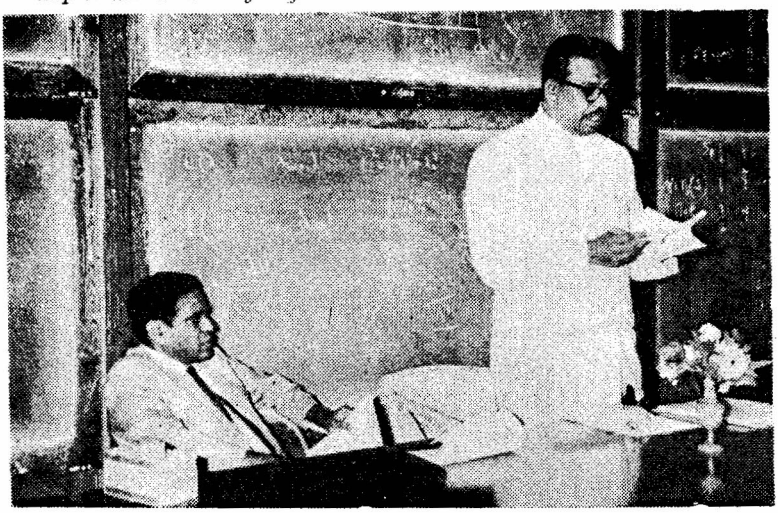
ALLADI RAMAKRISHNAN

Lal Bahadur Shastri

"It was only sixteen months ago that the mantle of Nehru, the apostle of a resurgent and re-awakened Asia, fell on him. He bore it with courage and confidence and under his leadership, the country emerged with hope and success through one of the greatest ordeals it had ever faced in its almost ageless history. Conscious of his responsibilities to a nation threatened by the invasion of its time-honoured frontiers, he displayed great magnanimity in agreeing to discuss his country's problems at the instance of the Soviet Government. He has left us in the manner of a 'Krithakarya' with the message that it is now time to 'unarm, for the long day's work is done.' Thereby he has earned the gratitude of thousands of millions of our country who 'can now look forward to the satisfactions' of safety assured, of peace restored, honour preserved, of the comports of fruitful industry, of the home-coming of the soldiers,' of the smiles of their wives and children. With all these will be mingled the ache for him who, in his hour of greatest triumph, could not come home."

ALLADI RAMAKRISHNAN

"I feel, Mathematics should be given due importance at all stages of education..."



Mr. V. R. Nedunchezhiyan, Minister for Education, inaugurating the seminar in analysis in 1967

Professor Vikram Sarabai, Chairman, Atomic Energy Commission with the director (1968)

INAUGURAL ADDRESS

BY

Mr. V. R. NEDUNCHEZHIYAN

Minister for Education, Government of Madras

at the Seminar in Analysis

20th December, 1967

I am indeed happy to be present here to-day and participate in the inauguration of the "Seminar on Mathematical Analysis" and I thank Dr. Alladi Ramakrishnan for having given me such an opportunity. While I feel the atmosphere and the environment of this Institute quite agreeable and pleasant, I should confess that I do not feel quite as at home with the subject that you are concerned with.

You would accept that there is nothing that I could discuss on your seminar topic proper. I shall take this opportunity only to discuss general points of interest, but still pertaining to your area of work.

I am one of those many who could neither understand nor appreciate higher mathematics in terms of its depth and breadth; but can stand at a respectful distance and wonder at what it has contributed to advancement of civilisation and human progress. If one ponders over it, one would be struck by the strange phenomenon, that while mathematicians withdraw more and more from the masses, and develop apparently abstract theories, their application brings about changes and developments that affect every aspect of our living. I am interested in Mathematics, not as a builder of the subject, but as a user of the many developments which have their origin and foundations in Mathematics.

There is one more aspect of Mathematics which is of interest to me, especially in my capacity as the Minister for Education. Most of us in the society either in a country like ours or even in advanced countries, employ only a knowledge of arithmetic in our career. Among those who study mathematics either in the schools or colleges, a small percentage may really use the algebra

and geometry they have studied. I feel, still, that Mathematics teaching should be given due importance at all stages of education because it is a discipline that develops the ability of logical reasoning and rational approach. One may or may not use the mathematics he learns, but every one benefits from the mathematical outlook he develops: I mean the scientific outlook that he develops as a consequence of the study of Mathematics Objective analysis, rigour in the demand for proof, precision in the use of language, are part of a highly cultured and developed mind and one could think of no other subject better suited to achieve this objective than a study of Mathematics. Being a non-mathematician, the meaning of your enquiry is obscure to me, but the methods you employ appeal to me very much and their educational values are immense.

I am told that Mathematics teaching in advanced countries is very much at a higher level than in our country. What is taught in our first and second year University classes is said to be completed in those countries in the high school itself. I also learn that enormous research is being done in the preparation of text books in Mathematics and in the development of teaching techniques that make the learning of Mathematics more easy and attractive. We are aware of the diffidence and fear with which majority of our students look at Mathematics. Arguing from a common sense point of view, I should say, that a subject so logical as Mathematics cannot be so frightful as it is imagined to be. There, perhaps, are some inadequacies in our method of teaching. All difficulties in learning are the difficulties of missing steps. If we could supply those links and fill up the gaps, this subject should become more popular and more appealing.

Advanced theories could be explained by an average person; but it needs a real master to explain the elementary concepts and fundamental notions. I would appeal to the mathematicians of this country not only to develop a high tradition of Mathematical discovery but also to develop a sound system of Mathematics teaching. As a minister for Education, all that I could say about Mathematics to an audience of mathematicians and physical scientists is that though I do not understand your equations, I do understand their importance and potential and I have great respect for the edifice that has been built on sound logical foundations.

I learn that the primary activity of your institute is creative research in Mathematical sciences. In an era that depends more

and more on the exploitation of the invention in sciences for the development of technology, and growth of material welfare, the need for developing high level talent in these sciences in our country is obvious. You are working in a field where nothing short of 'excellence' can be your goal. In industry there can be one standard for advanced countries and another for developing countries. In living conditions there could be, and there are, wide gaps; but in research in basic sciences there can be no two standards; we should work atleast at the same level as others in the field. No one would recognise a second rate contribution simply because it comes from a developing nation. If we want a Nobel Prize we should pay the prevailing price in the scientific world. You cannot bargain for discount on the plea that you belong to a developing country.

Whatever scarcity there may be in this country, there is not dearth of talented youngmen. No resource is so precious and valuable as the human resource. It is only a problem of educating and training the right people for right task. I am sure your institute will provide the country with men who would not merely be up-to-date but will be leaders in the field.

I cannot help looking back to the days when the science of Mathematics flourished in this land and contributions of immense significance were made by our thinkers. We should make untiring efforts to regain the leadership and partake in the contribution of knowledge as equals among other nations. Fortunately, you are working in an area where dependence on laboratory and equipment is minimum and what counts is intellectual calibre and guidance available.

All great contribution have emanated from centres that have a tradition and have been able to attract a team of dedicated men. I hope and wish that yours will be such a centre and I look forward to hearing in the not too distant future of achievements of which the nation can be proud of.

In the recent years there have been in India a number of seminars and summer schools. They were merely at the national level and intended to serve the purpose of an accelerated education programme in certain subjects. Yours I understand, is different in character. I learn that it would be international in character. From the list of members participating, I find that two out of the three main lecturers are from abroad.

I hope that their stay and work during the brief period would serve the purpose for which such seminars are arranged.

I take this opportunity to thank the foreign professors for their interest and concern for our work and development

Higher learning and research are necessarily things that do not permit mass participation. It is confined to a few in each area. But we must remember that we are enabled to carry on our work by mass support and this they do at considerable sacrifice in terms of their personal comfort and facilities. So, those of us engaged in academic work owe a great responsibility to the society at large and we should constantly bear this in mind. A sense of dedication and a spirit of mission should pervade our effort and activities. I wish this institution, being only one of its kind in India will set a noble example and develop high traditions that are in conformity with out past traditions and future programmes.

I am sure that the seminar, I am inaugurating, will further the objectives of this institution. I have great pleasure in declaring open the "seminar in Analysis" and wish it all success.

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Elementary Particle Physics

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Alladi Ramakrishnan	Theoretical physics in U.S.A., Current Science, **27**, 469 (1958).
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New perspectives on the Dirac Hamiltonian and Feyman. Proceedings of the 1967 Colorado Summer School (Gordon Breach).

Professor Alladi Ramakrishnan was invited by Professor W. Heitler of the University of Zurich to write a book on "Elementary Particles and Cosmic Rays". The book grew out in the process of training a group of research students at Madras in the new field of elementary particle physics and was published in 1962 by Pergamon Press (London).

This has been translated into the Russian language in 1968.

A book on "Pauli matrices and symmetry principles," to be published by the Academic Press is under preparation.

Field theory and Feynman graphs

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Alladi Ramakrishnan, R. Thunga and T. K. Radha	On the decomposition of the Feynman propagator, Proc. Ind. Acad. Sci. (A), 228 (1960)
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	A new form for the Feynman propagators, Jour. Math. and Physi. Sciences, Vol. I, June 1967, Nos. 1 and 2, p. 57)

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	Title & Journal
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	Helicity and energy as members of a Hierarchy of Eigenvalues, (Jour. Math. Anal. Appl., V. 23, p. 397–401, 1967)
	Symmetry operations on a Hierarchy of matrices, (Jour. Math. Anal. Appl., V. 22, p. 39–42, 1968)
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Alladi Ramakrishnan	L-matrices, Quaternions and Propagators, (Jour. Math. Anal. Appl., V. 23, p. 250–253, 1968)
	A Hierarchy of helicity operators in L-matrix theory, (I.I.T. Jour. Math. and Phys. Sci. Madras 1968, in press)
	On the Algebra of L-matrices, (Vol. 9 of Symposia in Theoretical Phys. and Maths., Plenum, in Press)
Alladi Ramakrishnan and R. Vasudevan	A Hierarchy of idempotent matrices, (Vol. 9 of Symposia in Theoretical Phys. and Maths., Plenum, in Press)

	Title & Journal
Alladi Ramakrishnan	L-matrices and propagators with imaginary parameters, (Vol. 9 of Symposia in Theoretical Phys. and Maths., Plenum, in Press)
	Generalised helicity matrices, (Jour. Math. Anal. Appl., in Press)
Alladi Ramakrishnan P. S. Chandrasekaran T. S. Santhanam and A. Sundaram	Helicity matrices for the generalised Clifford algebra, (Jour. Math. Anal. Appl., in Press)
Alladi Ramakrishnan P. S. Chandrasekaran and T. S. Santhanam	L-matrices and the fundamental theorem of spinor theory, (Vol. 10 of Symposia in Theoretical Phys. and Maths., Plenum, in Press)
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Alladi Ramakrishnan, P. S. Chandrasekaran, N. R. Ranganathan T. S. Santhanam and R. Vasudevan	The generalized Clifford algebra and the unitary group, (Jour. Math. Anal. Appl., in Press)
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	Idempotent matrices from a generalized Clifford algebra, (Jour. Math. Anal. Appl., in Press)
Alladi Ramakrishnan R. Vasudevan P. S. Chandrasekaran and N. R. Ranganathan	Kemmer algebra from generalised Clifford elements, (Jour. Math. Anal. Appl., in Press)
Alladi Ramakrishnan	Pageant of modern physics—Planck to Gell-Mann, (C.P. Ramaswamy Iyer memorial Volume, (Madras) in Press)

Invited lecturer and visitor at the following Institutions

University of Manchester, England

Dublin Institute for advanced studies, Ireland

Cramer's Institute, Stockholm

E. T. H. Zurich, Switzerland

The Australian National University, Canberra, Australia

The University of Melbourne, Melbourne, Australia

The University of Sydney, Australia

The Massachusetts Institute of Technology, U. S. A.

National Research Council, Ottawa, Canada

Case Institute of Technology, Cleveland, U. S. A.

Illinois Institute of Technology, Chicago, U. S. A.

Naval Research Laboratory, Washington, U. S. A.

Oxford University, Oxford, England

Atomic Energy Establishment, Harwell, England

Imperial College of Science and Technology, London

(Niels Bohr) Institute for Theoretical Physics,
Copenhagen, Denmark

Institute of Henri Poincare, Paris, France

University of Marburg, West Germany

University of California, Los Angeles, U. S. A.

Stanford University, Stanford, California, U. S. A.

University of California, Berkeley, California, U. S. A.

National Bureau of Standards, Washington, U. S. A.

University of Maryland, U. S. A.

Saclay, France

CERN, Geneva, Switzerland

University of Rome, Rome, Italy

University of Naples, Italy

University of Padua, Italy

University of Rochester, U. S. A.

University of Southern California, Los Angeles, U.S.A.

Tokyo University of Education, Tokyo, Japan

University of Hawaii, Honolulu, U. S. A.

University of Washington, Seattle, U. S. A.

Boeing Research Laboratories, Seattle, Washington

Advanced Research Laboratory, Douglas Corporate Offices, Huntington Beach, U. S. A.

University of California, Irvine, U. S. A.

St. Louis University, St. Louis, U. S. A.

University of Wisconsin, Milwaukee, U. S. A.

Institute of Theoretical Physics, M. I. T., Cambridge, U. S. A.

Boston University, Boston, U. S. A.

State University of New York, Buffalo, U. S. A.

Yeshiva University, New York, U. S. A.

Courant Institute of Mathematical Sciences, New York, U. S. A.

Cornell University, Ithaca, U. S. A.

McGill University, Montreal, Canada

Academy of Sciences, Moscow, U. S. S. R.

Physical Technical Institute, Academy of Sciences, Leningrad, U. S. S. R.

Aria-Mehr University, Teheran.

Visiting Scientist at the following Institutions

University of Sydney, Australia

Yukawa Hall, Kyoto, Japan

Institute for Advanced Study, Princeton, U. S. A.

University of Berne, Switzerland

The Rand Corporation, California, U. S. A.

University of Syracuse, New York, U. S. A.

Stanford University, Stanford, U. S. A.

Participated in the following International Conferences and Symposia of Research Institutions:

The International Conference on Theoretical Physics, Edinburgh, Scotland	1949
Meeting of the Physical Society of Great Britain, Birmingham	1950
Meeting at Cramer's Institute, Stockholm	1950
Symposia and Colloquia, University of Zurich	1951
Sixth International Conference on High Energy Physics, University of Rochester	1956
Conference on Applied Mathematics and Mechanics (GAMM) Stuttgart, West Germany	1956
International Conference on Elementary Particles, Venice, Italy	1957
Meeting of the Swiss Physical Society, Winterthur, Switzerland	1960
Symposium on Low Energy Nuclear Physics, Copenhagen, Denmark	1960
Symposium on Elementary Particles, Trieste, Italy	1960
International Seminar on Unified Field Theories, University of Rochester	1963
International Conference on Cosmic Rays, Jaipur	1963
International Conference on High Energy Physics, Dubna, U. S. S. R.	1964
International Conference on High Energy Physics, University of California, Berkeley	1966
International Theoretical Physics Conference on Particles and Fields, Rochester	1967
Summer Institute for Theoretical Physics, Boulder, Colorado	1967
International Conference on High-Energy Physics, Vienna, Austria	1968

International Centre for Theoretical Physics,
Trieste, Italy.

University of Colorado, Boulder, U. S. A.

Among other institutions to which he was an invited visitor or lecturer are :

University of Oslo, Norway.

University of Uppsala, Sweden.

University of Geneva, Switzerland.

University of Gottingen, W. Germany.

University of Heidelberg, W. Germany.

Simon Fraser University, Vancouver, Canada.

University of Toronto, Toronto, Canada.

Yerkes Observatory, University of Chicago, U. S. A.

University of Wisconsin, Madison, U. S. A.

California State College, Long Beach, U. S. A.